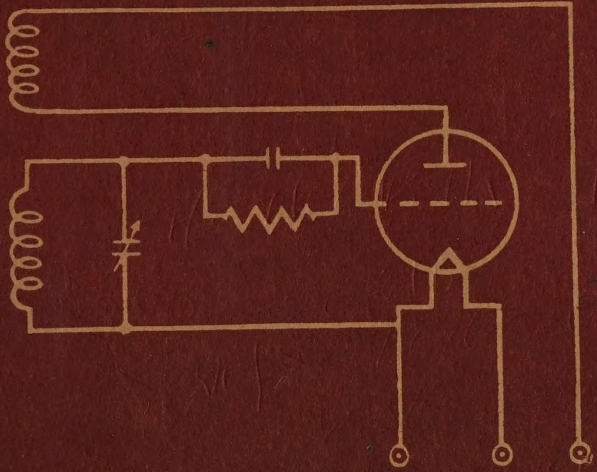
ALLIED'S RADIO-CIRCUIT HANDBOOK



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ALLIED RADIO CORPORATION
CHICAGO

O. T. Burton

ARC

ALLIED'S RADIO CIRCUIT HANDBOOK

A COMPREHENSIVE GROUP OF RADIO AND ELECTRONIC CIRCUITS WITH ANALYSIS, COMPARISONS AND DISCUSSIONS FOR STUDENTS AND EXPERIMENTERS

Compiled by the Technical Staff of
ALLIED RADIO CORPORATION

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ARC

FOREWORD

The purpose of this book is to illustrate basic radio principles by presenting, comparing, and analyzing some of the most popular conventional radio and electronic circuits. All diagrams cover dependable systems which are in actual use. Each circuit was carefully selected as the result of many years' experience of ALLIED'S *Technical Staff and Educational Division with radio students, instructors, experimenters and engineers.*

Fundamental principles are illustrated and explained by the "Basic Circuits" and the text in the first part of the book; then the application of these principles to various components of receivers, transmitters and other electronic units is shown. Thus the student gains a knowledge of how and why different circuits operate.

The method of presentation was especially planned to make this book a useful text for the classroom and for home study, as well as a reliable guide for experimenters and builders.

Most of the projects described in this publication are available in kit form. See your latest ALLIED *catalog.*

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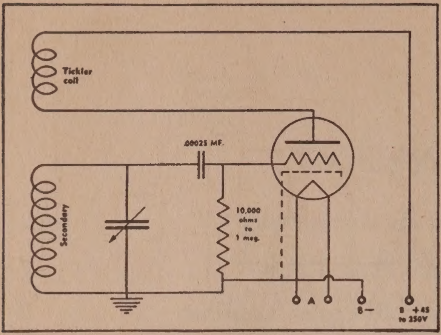
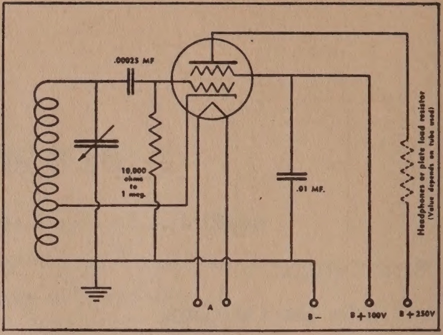
1 Tickler Coil Oscillator



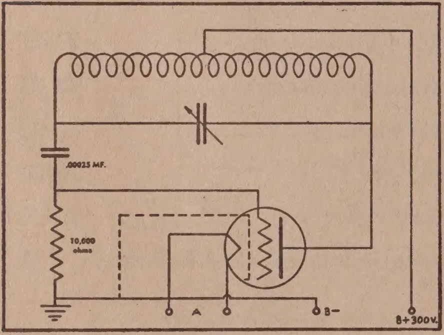
This type of oscillator is used in regenerative receivers and in the converter stage of superheterodynes. Oscillation is attained by feeding more energy from plate to grid circuit than the amount required to compensate for the power loss in the grid circuit. Feedback is accomplished by electromagnetic coupling between grid and plate coils. When fed-back energy is greater than the loss in the grid circuit, the tube oscillates at a frequency governed by coil and condenser values.

2 Electron-Coupled Oscillator


.00025 MF
10,000 ohms to 1 meg.
.01 MF.
Headphones or plate load resistor (Value depends on tube used)
A
B–
B+100V
B+250V

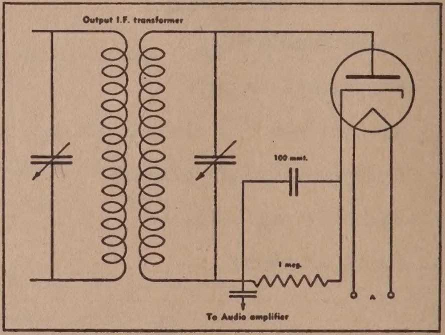
The single tapped coil operates as two separate coils, divided by the point at which the tap exists. The two parts of the coil, above and below the tap, are mutually inductive. Action is similar, otherwise, to that in the tickler coil oscillator (described at left). The tube elements, making up the oscillator, are the cathode, grid and screen grid. Oscillations are transferred to the plate circuit through the electron stream. Plate current variations do not affect stability.

3 Hartley Oscillator



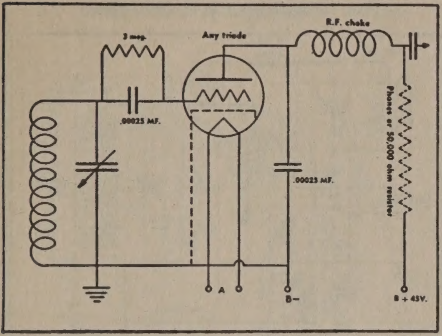
The Hartley oscillator is commonly used in transmitter circuits. Oscillation is produced by feeding back, from the plate to the grid, a voltage approximately 180° out of phase with the voltage in the plate circuit. This is accomplished by sending part of the plate voltage through the tank circuit, then through the condenser, and back to the grid. Frequency of oscillations is approximately the frequency of the tank circuit. The B tap on the coil should be made at a point of low R. F. potential.

4 Diode Detector



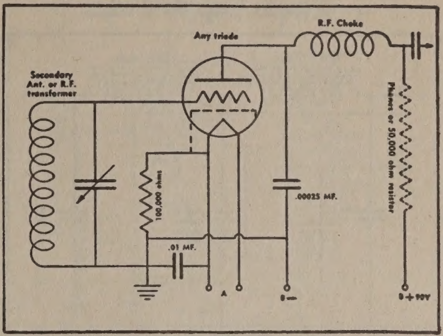
Action of a diode detector is like that of a half-wave rectifier. AC current (the modulated input signal) coming from the secondary of the transformer, flows through the plate only on the half cycle when the plate swings positive. The resulting pulsating DC current varies in accordance with the amplitude of the positive half of the modulated wave and produces an audio frequency signal. The condenser across the load resistor must be large enough to smooth out the RF pulsations but not too large, or it will short-circuit the audio signal.

5 Grid-Leak Detector



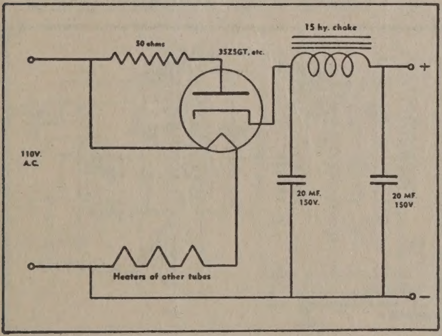
GRID-LEAK detector action resembles that of a diode detector with one added stage of amplification. The grid and cathode of the tube serve as a diode with the grid acting as a plate. The grid-leak resistor and the grid condenser act as an impedance that matches the load impedance of the diode detector. The .00025 mf. condenser in the plate circuit shorts out RF voltage that may have been amplified by the tube. Amplification of the signal voltage is provided by the plate.

6 Biased Detector



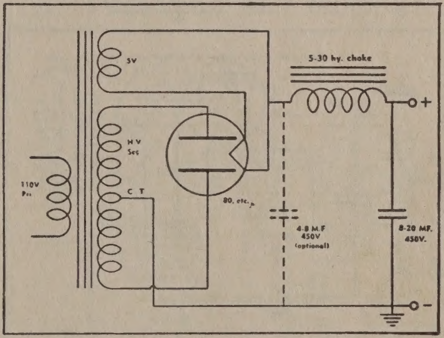
The grid is biased almost to cut-off because of the high value of bias resistor, and plate current is practically zero with no signal in the grid circuit. When a signal is received, amplification takes place, but more plate current flows on the positive half cycles than on the negative half cycles. This results in demodulation of RF signal in the plate circuit. Filtering of RF currents in the plate is accomplished by the RF choke and the .00025 condenser.

7 AC-DC Power Supply



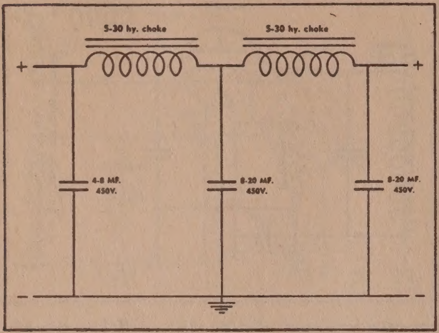
The function of a power supply is to provide DC power from an AC line. Operation closely resembles that of the diode detector circuit 4. Current flows only on the half-cycle when the plate is positive with respect to the cathode. High values of filter condenser are required to smooth ripple in the tube output since only one-half the AC wave is rectified, and the resulting pulsating DC has a 60-cycle AC component. The 50-ohm resistor protects the tube against the high current surges as the first filter condenser is charged and discharged.

8 Full Wave Power Supply



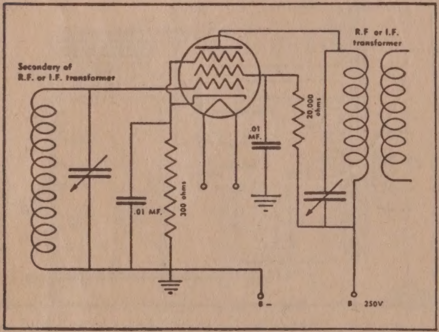
The diode used here has one filament and two plates. Current flows from each plate alternately on its positive half-cycle and results in pulsating DC, which is at twice the frequency (120 cycles per second) provided by a half-wave system. The full-wave system, since current flow is more uniform, is easier to filter than the half-wave system. The condenser, shown by dotted lines, increases output voltage but decreases regulation. Use of a power transformer provides higher voltages than those available from an AC-DC supply.

9 Power Supply Filter



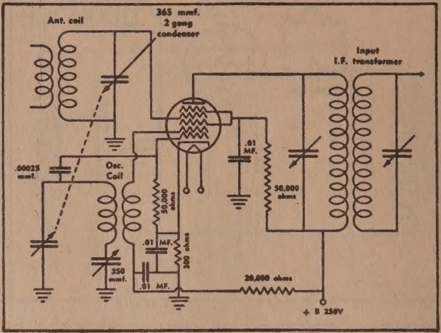
The function of the filter is to smooth pulsating voltage, supplied by the rectifier output, into steady DC voltage. Filter networks may be single- or double-section types; the latter provides better smoothing. Filter chokes should have high inductance and low DC resistance. Current-carrying capacity must exceed total plate current of all tubes plus any voltage dividers or bleeder resistors. Condenser voltage ratings should be higher than voltage between plus and minus.

11 RF Amplifier



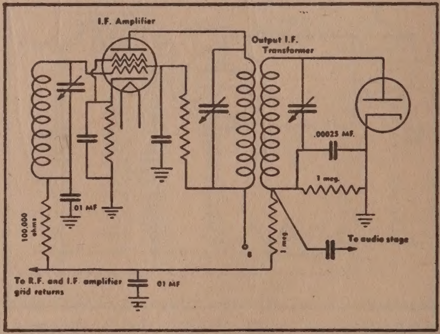
The principles of RF and AF amplification are the same. A small signal voltage impressed on a grid controls a large output in the plate circuit. The grid must be correctly biased, and the tube must work into the proper load impedance. Bias is obtained from the 300-ohm cathode resistor. Input and output circuits must be thoroughly isolated from each other to prevent oscillation. The necessary high load impedance is secured by use of the parallel resonant circuit. The system amplifies the desired signal and eliminates others.

10 Frequency Converter



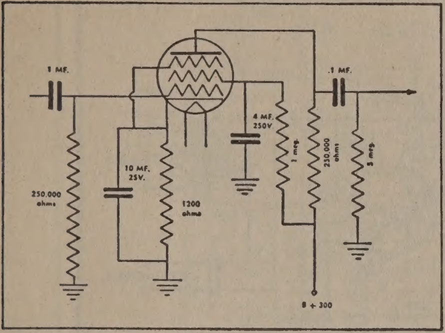
The frequency converter is used in superhets to change the frequency of the RF signal to an intermediate frequency. The tube used is called a "mixer." The cathode and grids 1 and 2 (from the cathode) comprise a tickler-type triode oscillator. Signals from the secondary of the antenna coil mix with the frequency of the oscillator and result in a new frequency, called the "intermediate frequency," which is equal to the difference between the two.

12 Automatic Volume Control



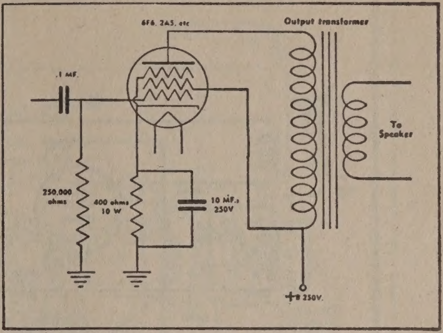
Automatic volume control is used to provide constant output despite variations (fading or more-than-normal increase) in signal strength. This circuit combines circuits 4 and 11. The rectified DC voltage developed across the 1-meg. diode load resistor is added to the bias voltage of the IF or RF amplifiers. When the signal decreases, the IF output tends to decrease, thereby decreasing the negative bias and increasing the gain of the amplifier. When the signal increases, the process is reversed and gain is reduced.

13 Audio Voltage Amplifier



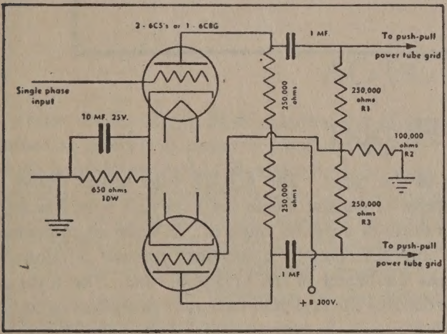
The tube is operated at proper grid bias to keep input grid voltage on the straight line of the grid voltage vs. plate current characteristics curve. A small signal voltage impressed on the grid is reproduced in essentially the same form, but in increased amplitude, in the plate circuit. The ratio between the signal voltage at the grid and plate voltage in the load resistance is the gain of the tube. In this circuit, gain is 140 if the tube used is a 6J7, 57, 6C6 or 6W7G.

14 Power Amplifier



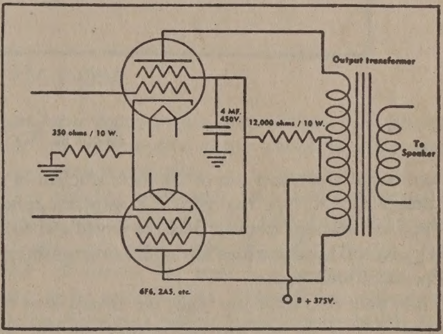
A power amplifier must supply large amounts of distortionless power to the loudspeaker. Power amplification is, therefore, more important than voltage amplification. A 6F6, 2A5 or similar type pentode tube may be used with the values of the components shown in the above circuit. The output transformer must have the proper ratio to match the output of the tube to the speaker voice-coil. This circuit is capable of 3 watts output.

15 Audio Phase Inverter

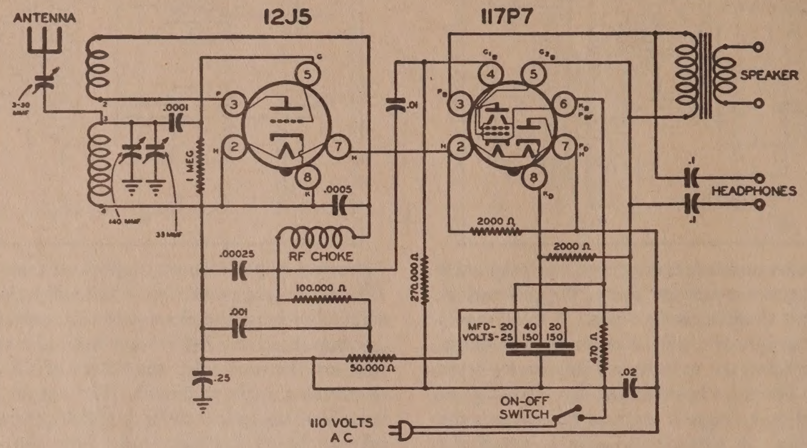


The function of the phase inverter is to feed signal voltages, 180° out of phase with each other, to the grids of a push-pull stage. When the grid in one tube is swung positive, the grid of the second is swung negative by an equal amount. The output AC voltage from the first triode appears across R1 and R2. The portion across R2 is fed to the grid of the second triode, and its output appears across R3 and R2 but out of phase with the voltage from the first triode. These out of phase voltages are fed to the grids of the P.P. amplifier.

16 Push-Pull Power Amplifier



Two 6F6 tubes are used in this amplifier. The same value of voltage is applied to the grid of each tube, but voltages are 180° out of phase. The outputs of the tubes are combined by the center-tapped output transformer. The direct currents in the two halves of the primary are in opposite directions, and so DC saturation is impossible. AC hum is eliminated because the two halves of the primary balance each other. P.P. provides more power per tube at less distortion. This circuit develops nearly 20 watts of power.



SCHEMATIC DIAGRAM
2 TUBE OCEAN HOPPER

AC-DC Ocean Hopper

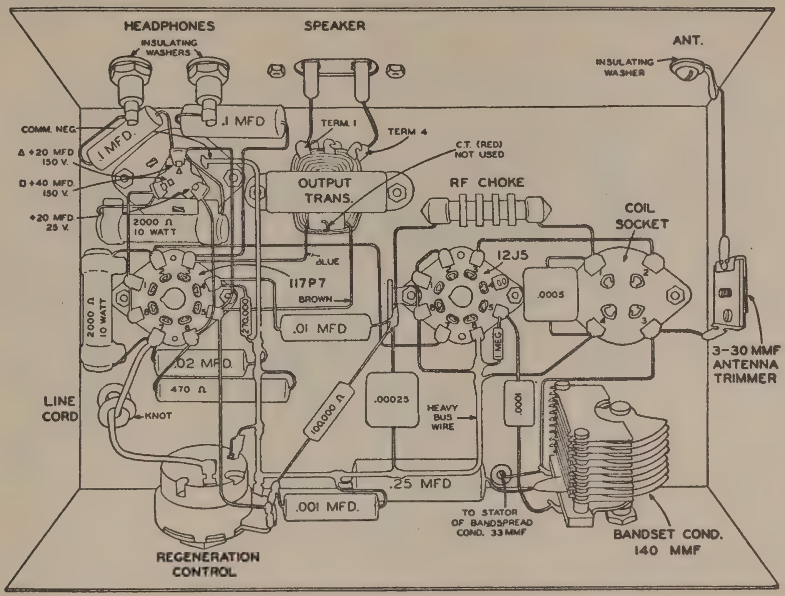
This circuit represents one of the most efficient of the simple AC-DC type receivers. It is sensitive enough to "pull in" stations from all over the world and on the more powerful local stations has sufficient amplification to operate a loudspeaker.

While only two tubes are used, the circuit is so well engineered that its performance is equal to that of a larger receiver. The 12J5GT tube, serving as a regenerative detector, is a detector-amplifier with a high amplification factor. The 117P7GT is a dual-purpose type, combining in one tube a half-wave rectifier and a beam power tetrode amplifier. As in the case of all AC-DC receivers, the filaments of the tubes are connected in series. The 12J5GT tube and the 117P7GT tube in series normally require 129 volts for proper operation. In this circuit, however, they operate efficiently on any line voltage from 110 to 130 volts. The lower the voltage as long as it stays above 110, the longer will be the life of the tubes. The 12J5GT tube heater draws .15 amperes of current while the 117P7GT tube has a current drain of only .09 amperes. In order to compensate for this difference, a 2,000-ohm resistor is connected across the heater of the 117P7GT tube. The total current drain of the 117P7GT tube and the resistor in parallel with it equals the current drain of the 12J5GT tube and maintains a balance in the heater circuit.

The .0005 and the .00025 mfd. mica condensers between the RF choke and ground filter out any RF voltage in the output of the detector.

The .01-mfd. coupling condenser passes the audio signal from the detector to the power amplifier without passing DC current which would adversely affect the grid bias on the power amplifier tube.

The filter circuit design is extremely efficient. By using the unusually high total of 80 microfarads, practically all hum is eliminated. This obviates the need



PICTORIAL DIAGRAM

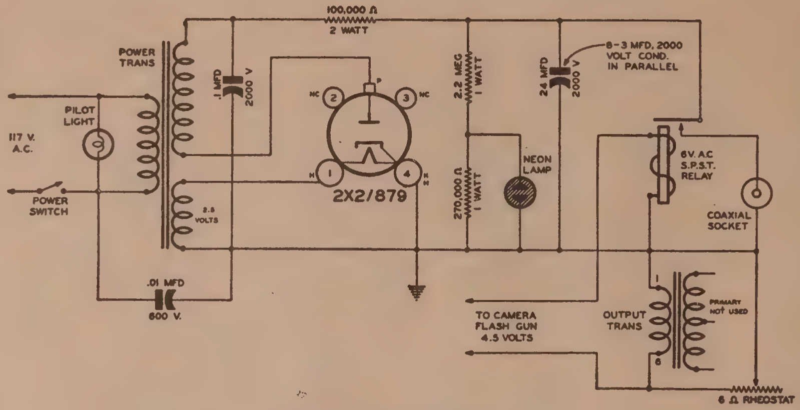
AC-DC Ocean Hopper

for a filter choke. Thus, highly dependable filtering is attained at greatest economy of parts and wiring.

Both headphones and loudspeaker operation are accomplished without circuit changes. High-impedance headphones are connected to the output of the 117P7GT power amplifier through condensers. For loudspeaker use the speaker-matching transformer connected to the same point reduces the impedance of the output to match the speaker voice coil.

Six tuning coils cover from 9.5 to 550 meters (550 kilocycles to 31.5 megacycles). These coils are standard plug-in types for use with the 140-mmfd. (.00014 mfd.) midget variable condenser. Each coil consists of two parts, a primary or tickler winding, and a secondary or main winding. The mutual inductance between the two parts produces oscillation. Regeneration is controlled by the DC voltage in the plate circuit of the tube. Increasing the voltage increases regeneration. In general, regenerative detectors are characterized by high sensitivity and will receive either phone or code signals without circuit changes.

Two variable condensers are connected across the secondary winding for tuning. One is the main tuning condenser (140 mmf.) and the other is the "bandspread" condenser (33 mmf.). The bandspread condenser, as its name implies, "spreads" stations farther apart on the tuning dial and is a feature usually found only in the higher-priced communications receivers. It is of particular importance on short-wave stations, for these are crowded so close together that attempting to tune them without "bandspreading" is a difficult and annoying task. "Bandspreading" also enables the "DX'er" to pick up many of the distant stations that would otherwise be lost because of some local that covers too much of the dial. The 3-30 mmfd. trimmer compensates for loading effect of the antenna.



SCHEMATIC DIAGRAM
HIGH-SPEED PHOTO FLASH

Electronic High-Speed Photoflash

This unit is a new-type electronic high-speed photoflash whose tremendous speed (1/15,000th of a second) stops practically any action. It eliminates the need for photoflood lamps in indoor photography, is always ready for instant use, and its economical operation of approximately one cent per flash is a money-saver for those who do a great deal of indoor photography.

The circuit consists essentially of three parts: (1) High voltage power supply; (2) energy storage capacitor; (3) flash (glow) lamp. Theory of operation is simple.

The 2,000 volt output of the power supply is used to charge the energy storage capacitor, which in turn discharges the full 2,000 volts across the glow lamp, causing its gas to "strike" and conduct the stored voltage. Since the total resistance of the glow lamp is only 6 ohms at the moment that it conducts, the result is a brilliant, instantaneous flash of light. The amount of light is tremendous, and despite its brief duration, is sufficient to assure splendid photographic results.

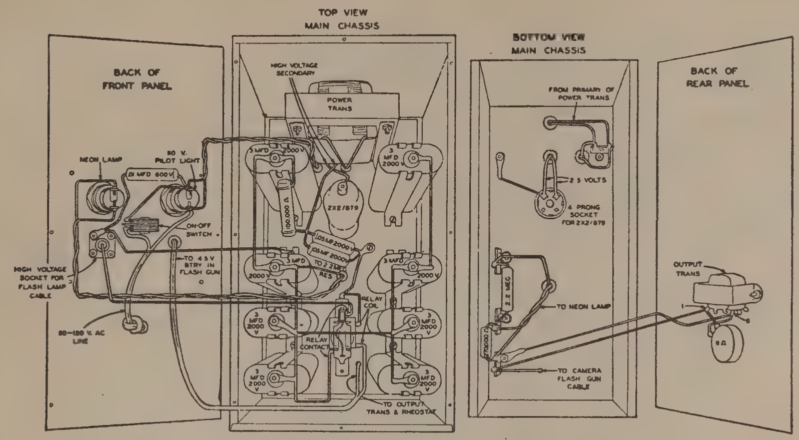
The high voltage power transformer has a 120-volt primary, a 2.5 volt secondary and a 1500 volt secondary. The 1500 volts is applied to the rectifier tube, and is built up to a peak value of approximately 2000 volts DC, by means of the .1 mfd. condenser. (Note: Two .05 condensers are used in parallel to give .1 mfd. of capacitance.) This 2000 volts DC in turn charges up a bank of condensers through the 100,000 ohm resistor. The resistor is used to keep peak charging current down and to protect the rectifier tube and transformer.

For economy of replacement, eight separate 3 mfd. condensers connected in parallel are used in place of a single "energy storage capacitor."

A single pole single throw relay closes the circuit between the condenser bank and the glow lamp, thus initiating the flash. The relay has a 6 volt AC coil which operates very satisfactorily on the 4½ volts that is standard in many photoflash synchronizers.

The "Charge Indicator" circuit consists of the following: the 2.2 megohm resistor, the 270,000 ohm resistor, and the neon bulb which lights up when all the condensers are completely charged up and ready to "strike" the flash lamp.

The flash lamp is installed in a standard reflector. It is connected to the power supply by means of a coaxial



PICTORIAL DIAGRAM

Electronic High-Speed Photoflash

cable which gives maximum insulation against the dangerous 2,000-volt jolt of the power unit.

The energy fed to the flash lamp by this unit amounts to 58 watt-seconds. The formula for this is $\frac{CE^2}{2}$, where C is in mfd. and E is in kilovolts.

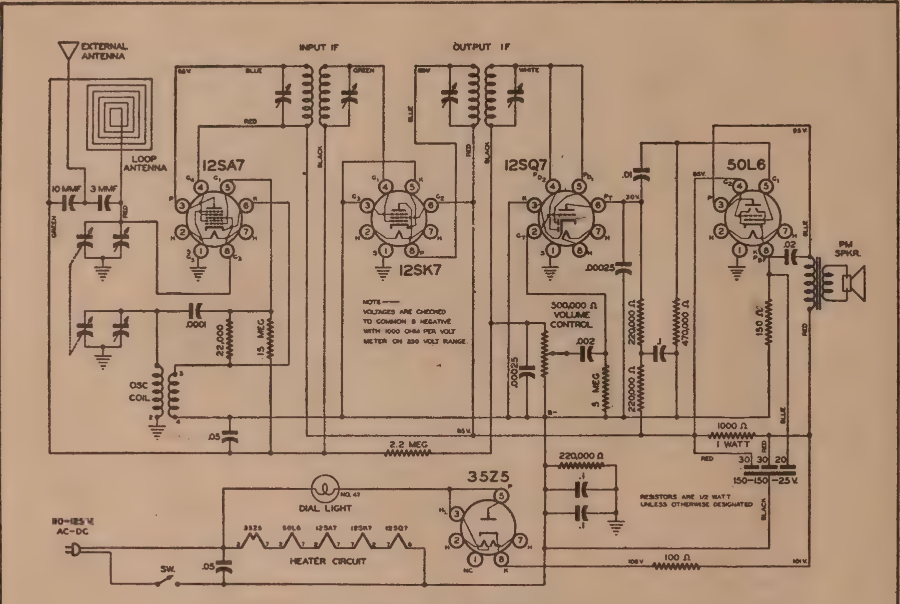
If the relay in the unit operates too fast for the release mechanism on the flash gun, an impedance is added to slow down the relay. A 6 ohm rheostat across a reactor enables accurate adjustment, and easy synchronization between the flash gun and the high-speed flash unit is possible. The unit will not synchronize with a camera that has a focal-plane shutter. However, for cameras equipped with this type of shutter only—or cameras without flash attachments — the "open-flash-shut" method is used.

Probably the greatest value of this unit lies in the field of portrait photography, especially of children. With this unit, the portrait subject is not exposed to the heat and glare of photofloods. Further, besides stopping the action of children, the tremendous speed of the flash permits the camera to record the natural appearance of the subject's eyes. The pupils will be large, and the eyes will appear bright. Fleeting facial expressions are caught easily with no trace of movement. In addition, where indoor photography is done on a large scale, the high-speed photoflash will save money. Approximately 5,000 flashes may be expected from one glow lamp, which brings the cost per flash (considering the cost of the entire unit) to about 1¢.

In order to study the portrait subject and make the necessary adjustments for proper lighting, only a small household-type bulb in a reflector is used. After the proper position for the flash lamp has been determined, and camera adjustments have been made—the household lamp is replaced by the photoflash lamp.

For the average fast film at a lens opening of f-11, approximately 6 feet between the photoflash lamp and the subject gives best results. However, since reflectors vary in their light-reflecting efficiencies and light-concentrating qualities, it is customary to make preliminary tests to determine proper exposure for the particular reflector being used.

The light given off by the photoflash lamp is bluish white, and therefore daylight film speeds are used. For color work, outdoor color film is used.



KNIGHT "RANGER"
5 TUBE AC-DC SUPERHET

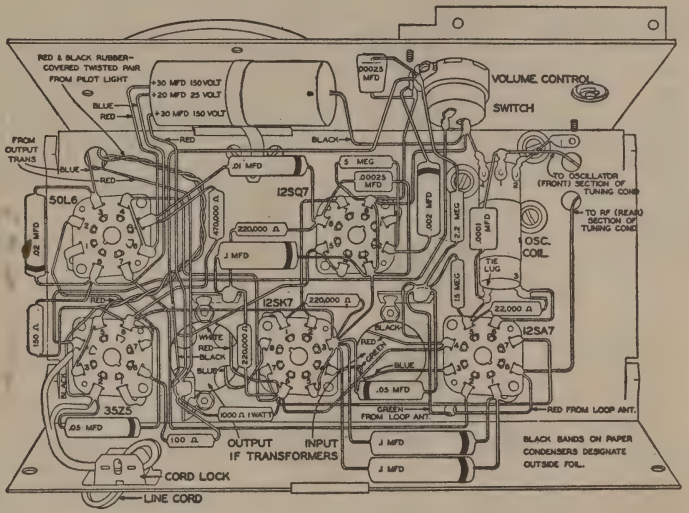
5 Tube AC-DC Superhet

This circuit has many unusual features that make it worthy of study. It is so designed that the heaters of the tubes, connected in series, may be operated directly from the 120-volt line without a dropping resistor. The heaters add up to 122.8 volts, but will operate from line voltages as low as 105.

The 12SA7 tube is the converter. It produces local oscillations at a frequency which can be varied. These oscillations beat with the incoming signal, and the combination of the two signals produces a beat signal known as the heterodyne signal. The name "Superheterodyne" is derived from the action. Heterodyning is used to change the incoming signal frequency to a predetermined intermediate frequency (known as I.F.) of 455 KC. The loop antenna is nothing more than an antenna coil, wound so that it is large in size and therefore capable of direct pickup of radio signals without the necessity for an external antenna. However, if an external antenna is desirable, it may be connected to the center of the condenser network across the loop antenna without greatly disturbing the tuned circuit (see schematic diagram).

In order to obtain an I.F. frequency of 455 KC, the oscillator must produce RF voltage at a frequency which is 455 KC higher or lower than the incoming signal frequency. In broadcast band receivers it is customary for the oscillator to be 455 KC higher. While the antenna section of the two-gang tuning condenser tunes the loop to resonate with signals from 1730 KC to 540 KC, the oscillator section of the tuning condenser varies oscillations from 2185 KC to 995 KC. The oscillator section of the tuning condenser has a lower maximum capacity. The oscillator coil has lower inductance than the antenna coil, or loop, and the oscillator section of the condenser and oscillator coil are designed to "track" with the antenna circuit.

The I.F. stage amplifies at high efficiency because its function is to amplify only one fixed frequency. It is



BLACK BANDS ON PAPER CONDENSERS DESIGNATE OUTSIDE FOIL.

PICTORIAL DIAGRAM

5 Tube AC-DC Superhet

also possible to obtain high amplification because of the comparatively low I.F. frequencies.

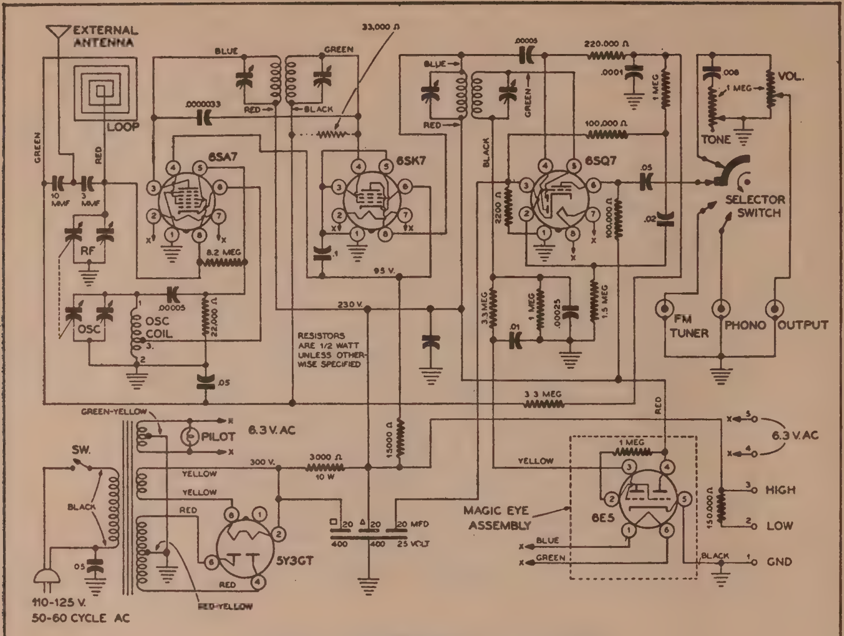
The converter and the I.F. tubes secure minimum fixed grid bias in a rather clever way. A DC negative voltage appears at the grid of all oscillators. In this circuit the oscillator portion of the converter tube produces a negative voltage at the control grid (terminal marked "G_1") of the 12SA7 tube. A negative grid bias voltage for the converter and I.F. tube is taken from this point. It is reduced to the proper value by the 15-megohm resistor.

The triode amplifier portion of the 12SQ7 detector-AVC-audio amplifier stage is biased by contact potential. This method of biasing makes it possible to ground the cathode. The negative side of the DC voltage developed across the volume control, which is the diode load resistor, is then connected through the 2.2 megohm resistor to the negative returns on the converter and intermediate frequency stages. This is the automatic volume control circuit.

The power stage is conventional except for the .02 mf. condenser which supplies an out-of-phase voltage from the plate to cathode, resulting in inverse feedback for improved quality.

The speaker is a permanent magnet type and its 3.2 ohm impedance is matched, through a speaker transformer, to the 2500 ohms of the 50L6 tube.

The power supply does not require a choke because capacitance values are sufficiently high for good filtering. The 35Z5GT rectifier has a tap on its heater for connection of the pilot lamp. The plate connection of the 35Z5GT is also made from the tap rather than in the old standard way, off the 120-volt line. With this arrangement the lamp burns dimly when the set is first turned on and comes to full brilliancy as the tubes warm up sufficiently to provide plate current. This prevents pilot lamp burnouts. It also absorbs current surges to the filter condenser.



HI-FI SUPERHET TUNER

High-Fidelity Superhet Tuner

The Knight Hi-Fidelity Superhet Tuner has been designed for set builders who want the best in quality radio reproduction. When built according to its carefully engineered specifications, its operation will compare favorably with the finest commercial tuners of the same type.

In a superheterodyne circuit, the incoming radio frequency (RF) signal is mixed with another radio frequency signal generated by a tunable oscillator in the receiver. This produces a new RF signal whose frequency is either the sum or the difference of the incoming RF signal and the signal generated by the local oscillator. This sum or difference frequency is known as the intermediate frequency and is usually abbreviated "IF."

Let us take a numerical example to determine how the intermediate frequency is obtained. In this hi-fi superhet tuner an IF of 455 kilocycles (kc) is used. This means that the IF transformers are fixed-tuned to 455 kc.

If the station we wish to receive is transmitting on a frequency of 1000 kc, the oscillator must produce a signal voltage whose frequency is either 545 kc or 1455 kc. In most broadcast receivers, the oscillator frequency is usually higher than that of the incoming signal, and in this case, it is 1455 kc.

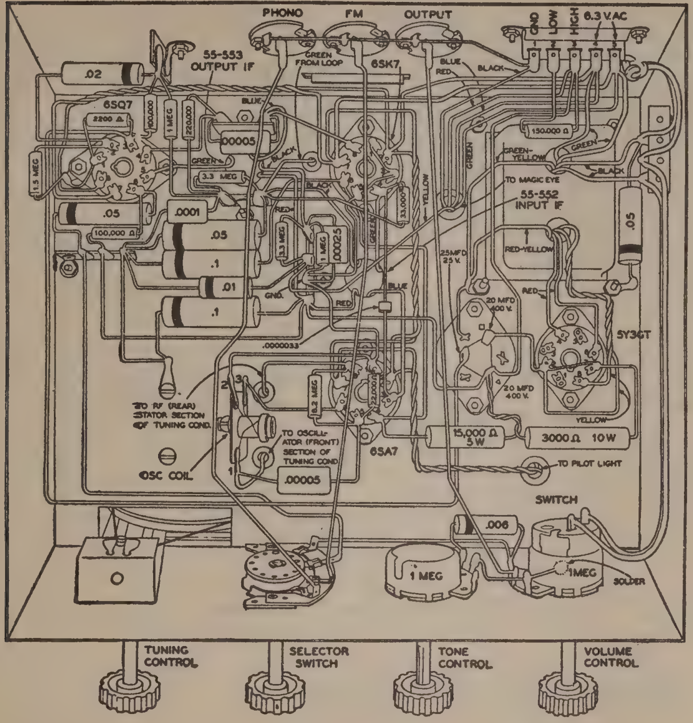
This Hi-Fidelity Superhet differs from a conventional superhet in one important respect—in addition to providing a fair degree of sensitivity and selectivity such as characterizes the standard superhet, it also achieves a wide band pass that permits superb high-fidelity reproduction.

In the conventional superhet circuit the prime factors are:

(1) greatest possible sensitivity
(2) greatest possible selectivity

To accomplish these it is necessary to use sharply

NOTE—BLACK BAND ON CONDENSER DESIGNATES OUTSIDE FOIL



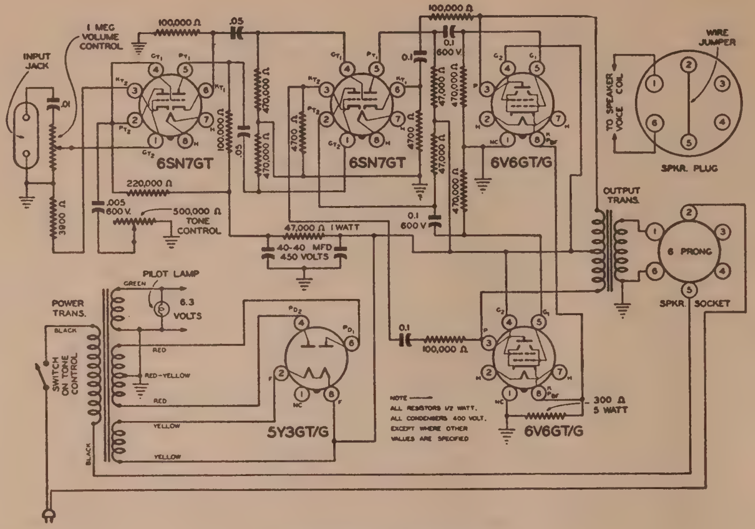
High-Fidelity Superhet Tuner

tuned circuits, particularly in the IF stages, and since amplitude modulated signals have a band width of about 10 kc, the sharply tuned conventional superhet circuit fails to reproduce a considerable percentage of the high fidelity intelligence sent out from a broadcast-station antenna.

For high-fidelity reproduction it is necessary for a tuner to pass as much as possible of the full 10 kc broadcast signal. In the Knight Hi-Fidelity Superhet, wide band pass coverage of the modulated RF signal is accomplished in the second detector. An additional sharply tuned circuit is used for the magic-eye to assure easy pin-point tuning to the exact center of the carrier frequency.

In operation, two diode sections of the 6SQ7 tube are used separately, one for the magic eye and one for detection of the signal. Broad-band tuning for detection is accomplished by coupling the diode section used for detection of the signal to the primary of the second IF transformer. Wide band selectivity is achieved in the first IF stage by a slight amount of over-coupling between the primary and secondary windings of the first IF transformer, and by a small amount of out-of-phase voltage which is fed back from the secondary to the primary by the 3.3 mmfd. condenser between the grid of the 6SK7 and the plate of the 6SA7 tube.

In other respects the Knight Hi-Fidelity Tuner resembles any other superhet. The IF frequency is 455 kc. The audio output voltage is about 5 volts and a good amplifier is required to complete the instrument. The tuner was designed for use with the 10-watt high-fidelity amplifier described on the next page. The two, when used together, form a receiving system that provides finest quality performance with fidelity equal to that of a receiver costing much more than these two units.



SCHEMATIC DIAGRAM

10 WATT HI FIDELITY AMPLIFIER

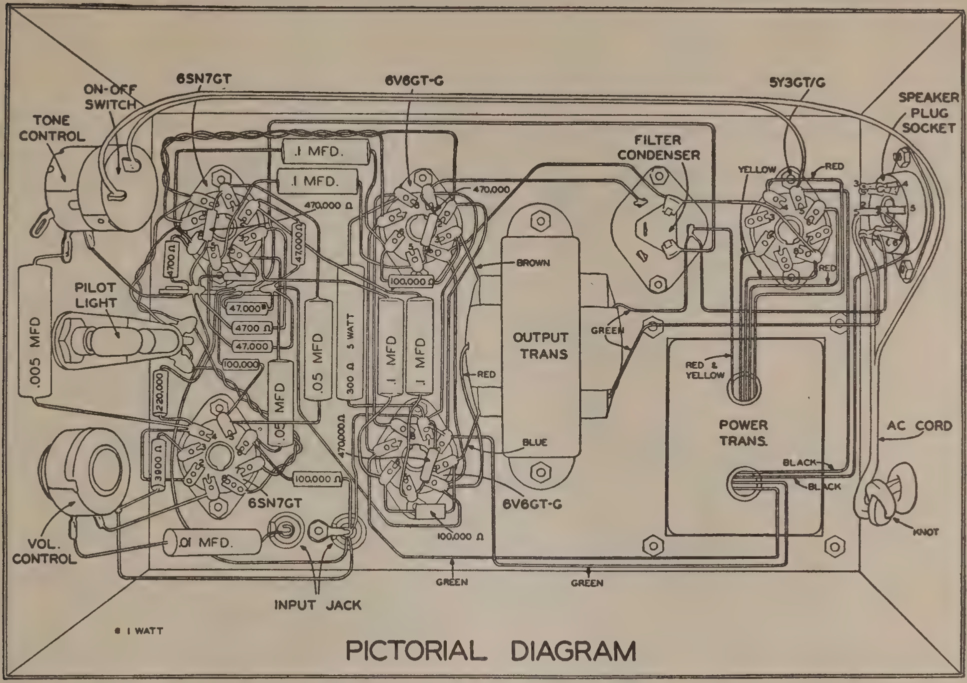
10 Watt Hi-Fi Amplifier

THE features incorporated in this circuit were selected to assure high fidelity reproduction and better overall performance. Inverse feedback is used to reduce distortion; direct coupling between the triodes of the first 6SN7GT eliminates the need for a coupling condenser and assures better low-frequency response; five tubes, two of which are 6SN7GT dual-purpose types, provide seven-tube performance.

In operation the signal applied to the amplifier input appears at the grid of the first triode of the first 6SN7GT tube. Bias is developed in the 3,900-ohm cathode resistor which is left unbypassed to provide inverse feedback in this stage. The second triode of the first 6SN7GT is connected as a balanced phase-inverter. As a result of the high value resistor in its cathode circuit a bias of about −50 volts is developed between grid and cathode. Since this tube operates best with about −1 volt bias, a positive voltage of about 49 volts is applied to it from the power supply. The difference between the +49 and −50 volts leaves the desired negative of 1 volt. This makes it possible to connect the plate of the first triode directly to the grid of the second triode, thus eliminating capacity coupling between them.

The second triode section of the first 6SN7GT is a balanced phase inverter, so called because the resistors in both plate and cathode circuits are of equal value and voltages appearing at those points are equal, but out of phase. These voltages are applied to the two grids of the second 6SN7GT tube through the .05 mfd. coupling condenser.

The second 6SN7GT tube acts as a push-pull voltage amplifier to the 6V6GT push-pull output tubes. The inverse feedback circuit consists of the 100,000-ohm resistors and the 1.0-mfd. condensers connected in series between the plates of the 6V6GT tubes and the cathodes of the two triodes in the second 6SN7GT tubes.



PICTORIAL DIAGRAM

10 Watt Hi-Fi Amplifier

A pair of 6V6GT beam power tubes are used in the power stage because of their high power sensitivity. When used in this or any other type of inverse feedback circuit, they retain much of their high power factor and, in addition, they take on the low plate impedance characteristics of triode stages.

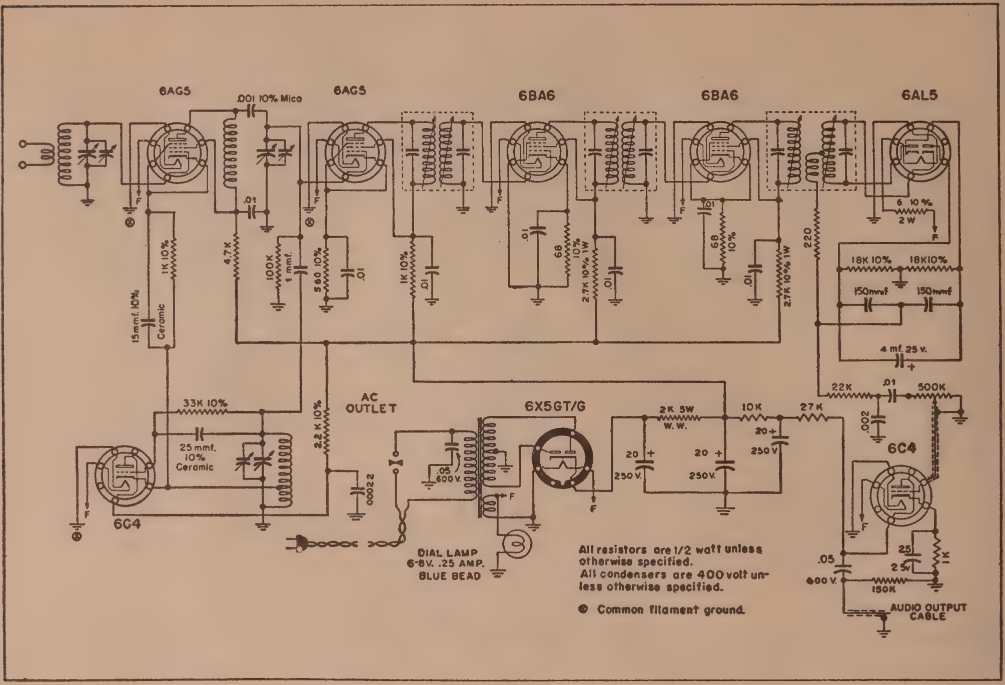
The output transformer matches the 8-ohm voice coil of a PM (permanent magnet) speaker to the optimum load into which the power stage should operate. The 40-mfd. electrolytic condenser provides sufficient filtering for stages in push-pull because of its hum-cancelling characteristics. The additional 40-mfd. condenser and 47,000-ohm resistor filters out any additional hum that may remain and results in a hum-free voltage supplied to the other stages of the amplifier.

The method of connecting the speaker plug is a valuable safety feature. Note that one side of the AC current supply passes through the speaker socket. A jumper between prongs 2 and 5 on the speaker plug completes this circuit. This arrangement keeps the amplifier from being turned on when the speaker is disconnected and prevents damage to the output transformer or tubes.

Any crystal or high-impedance magnetic phono pickup with an output of at least .5 volts may be used with the amplifier. The black lead or shielding, whichever is supplied with the pickup, is connected to the grounded input terminal, and the other lead to the terminal to which the .01 mfd. condenser is connected.

The tone control consists of a .005 mfd. condenser in series with a 500,000 ohm variable resistor between plate of the first triode and ground.

This amplifier is a splendid companion unit for the Hi-Fi Tuner described on the preceding pages. When used together, the two comprise a high-fidelity receiving system that is hard to beat.

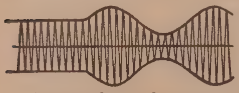


All resistors are 1/2 watt unless otherwise specified.
All condensers are 400 volt unless otherwise specified.

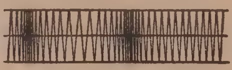
⊗ Common filament ground.

Frequency Modulated Tuner

Before the operation of an FM receiver is described, it is well to review briefly the theory of FM transmission. Unlike amplitude-modulated (AM) transmission in which the RF wave varies in amplitude to correspond with the impressed audio signal, frequency-modulated transmission does not affect the amplitude of the wave. It permits the wave amplitude to remain constant but varies wave frequency in accordance with the modulated signal.



Amplitude Modulation
Frequency remains constant.
Amplitude is modulated.

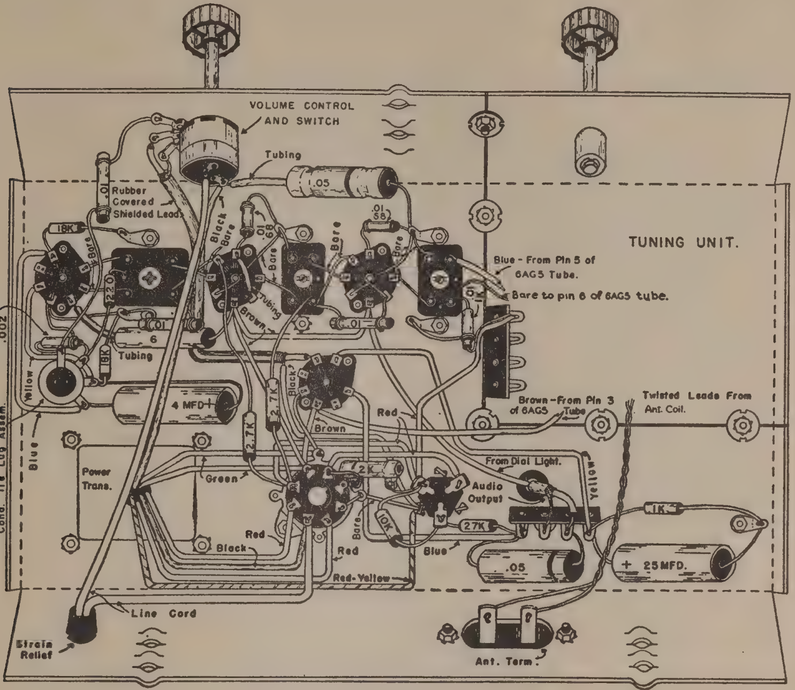


Frequency Modulation
Amplitude remains constant.
Frequency is modulated.

If the carrier frequency of an FM broadcast station is, let us say, 88 megacycles, its frequency under modulation may shift as high as 88,075 KC and as low as 87,925 KC. From this it is seen that a single FM broadcast station may cover a band width in the radio frequency spectrum of as much as 150 KC. This is why FM broadcast stations are located in the ultra-high frequency bands where there is a great deal more room for wide-range high-fidelity transmission than in the regular broadcast band.

The FM Tuner circuit described here was designed by Meissner Manufacturing Co., engineers. It employs a double converter system which greatly reduces image response.

The detector circuit, built around the 6AL5 tube, is called a "ratio detector." It develops an audio voltage that is proportional to the ratio of the swing in frequency above and below the average frequency during frequency modulation (FM). It responds only to FM signals, not to amplitude modulated (AM) signals,



Frequency Modulated Tuner

and since static and other electrical disturbances are principally amplitude modulated, they are not reproduced, thus performance of the FM receptor is noise-free.

The input or antenna coil tunes the entire FM band from 88 to 108 mc. The oscillator involving the 6C4 tube shown in the lower left of the schematic beats with the incoming signal to produce a lower frequency signal. The oscillator voltage is injected into the main receiver circuit at two points, in series with the cathode of the first 6AG5, and in shunt with the input grid of the second 6AG5. After the second 6AG5, the signal is at a 10.7 megacycle frequency and is amplified by the two following 6BA6 IF tubes.

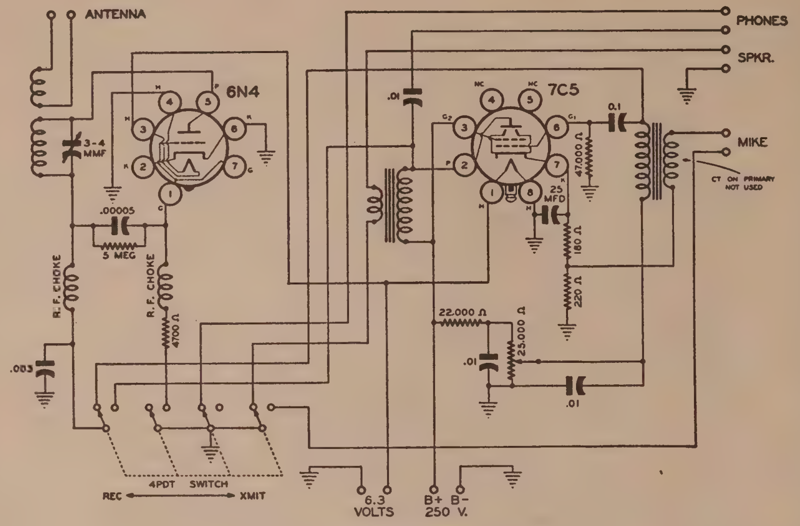
Just above and to the left of the 6C4 audio amplifier tube in the schematic drawing is a 22,000 ohm resistor and a .002 mfd. condenser. This is the de-emphasis circuit of the FM receiver. FM signals are transmitted with the higher frequencies accentuated. At the receiver, these higher frequencies must be attenuated to provide perfectly flat response. Any noise in the circuit is also reduced at this point.

A standard AC power supply using full-wave rectification is employed. The filter circuit is a resistor-condenser type, which is adequate since the tubes used draw very little plate current.

The output from the 6C4 amplifier tube is approximately 7 volts maximum. This is just right for use with any phono-amplifier, power amplifier or radio set having phono input terminals.

Because of the high frequencies involved it is desirable to use an outdoor antenna, which should be mounted as high as possible.

The alignment of an RF section would ordinarily require the use of test equipment. Therefore, when this tuner is purchased in kit form, the RF section is supplied completely assembled, wired and aligned.



SCHEMATIC DIAGRAM
2 METER TRANSCEIVER

2-Meter Transceiver

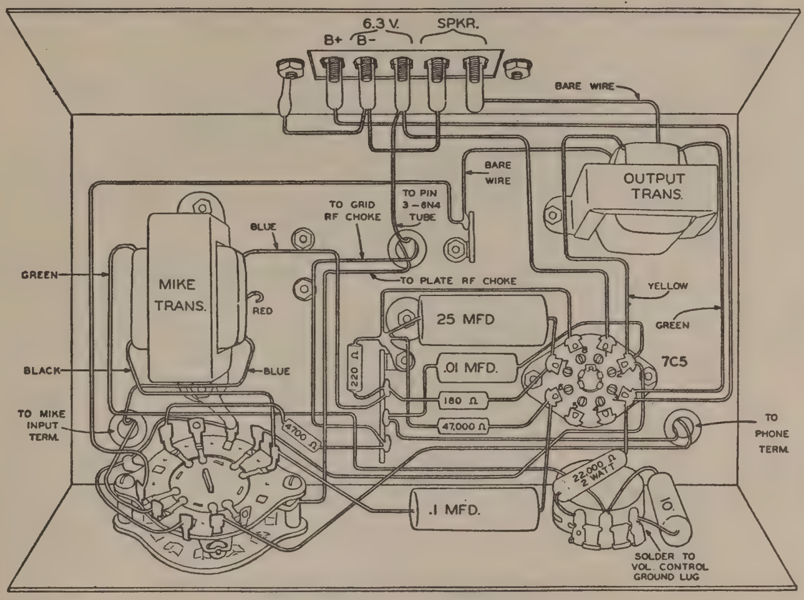
A "TRANSCEIVER" is an instrument built as a single unit to alternately perform the functions of reception and transmission. The circuit described here is that of a 2-meter amateur transceiver for use in the new amateur band between 144 and 148 megacycles.

Although any triode with low interelectrode capacities may be used in this circuit as an oscillator or super-regenerative detector, the 6N4 is a miniature type especially designed for high frequencies. The 7C5 tube serves as a modulator or audio amplifier. When used as a modulator, its grid circuit is excited by a simple single-button microphone, connected to an appropriate microphone transformer.

The position of the switch on the front of the transceiver panel determines whether the tubes are to be used for receiving or transmitting. When the switch is in the "Receive" position, the 6N4 tube acts as a super-regenerative detector, and its output (the audio frequencies) is fed to the grid of the 7C5. Here the audio frequencies are amplified and impressed on the headphones which are in the plate circuit of the 7C5 tube. One lead from the phones is switched to ground to complete the circuit. A speaker may be used if desired.

When the switch is in the "Send" position, the plate circuit of the 6N4 tube is connected in series with the plate circuit of the 7C5 tube. In this position the junction of the 4700-ohm and the 5-megohm grid leak resistors is grounded, and only the 4700-ohm resistor is effective as a grid leak. This results in lower grid bias, higher plate current and stronger oscillations for transmission.

The values of the component parts used in connection with the detector, especially the value of the grid-leak, causes the detector tube to oscillate at a super-regenerative frequency in the "Receive" position. Actually the tube oscillates at two frequencies, one at the RF fre-

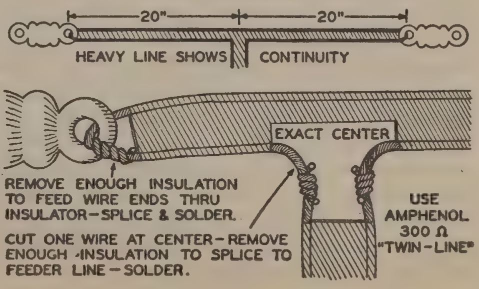


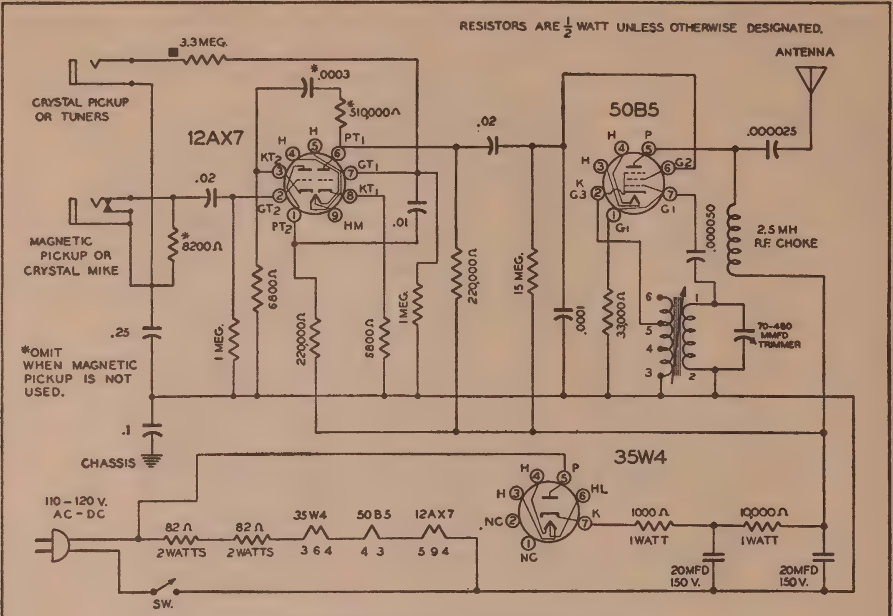
PICTORIAL DIAGRAM

2-Meter Transceiver

quency in the 2-meter band to which the coil is tuned, the other at a frequency above the audio spectrum, depending upon the value of the grid-leak used. Super-regeneration is also the result of the fact that the grid-leak return is to +B rather than ground, which would be the conventional practice. A super-regenerative detector is extremely sensitive—much more so than an ordinary regenerative detector. It is not used on other bands because it tunes too broadly and would pick up transmissions from several stations at once. It is ideal, however, for reception of signals from other transceivers because the transmitted signal in the high-frequency area used is normally broad. Super-regenerative receivers are so sensitive that electron noise in the tube can be heard as a hiss in the headphones. The hissing is apparent only between stations and disappears when a signal is picked up.

One of the most efficient and easily erected antenna is the "folded dipole" shown in the small sketch. Both the 40-inch antenna and matched feeder are made of Amphenol 300-ohm "Twin-line." A 2-turn twisted link line couples power from the coil to the antenna terminals.


20"
20"
HEAVY LINE SHOWS CONTINUITY
EXACT CENTER
REMOVE ENOUGH INSULATION TO FEED WIRE ENDS THRU INSULATOR—SPLICE & SOLDER.
CUT ONE WIRE AT CENTER—REMOVE ENOUGH INSULATION TO SPLICE TO FEEDER LINE—SOLDER.
USE AMPHENOL 300 Ω "TWIN-LINE"



RESISTORS ARE ½ WATT UNLESS OTHERWISE DESIGNATED.

*OMIT WHEN MAGNETIC PICKUP IS NOT USED.

SCHEMATIC DIAGRAM

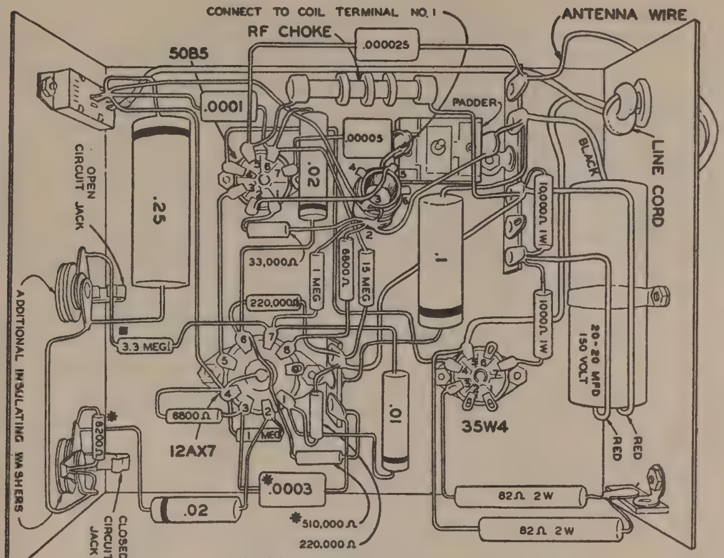
Wireless Broadcaster

The Wireless Broadcaster transmits modulated radio signals in the broadcast band, acting as a miniature broadcast station with limited range. It permits the playing of phonograph records or the making of "radio" announcements through a radio set without the necessity of direct connection to the set itself. The carrier signal is adjustable to a point on the dial of the radio where no broadcast station is heard. Either a crystal or new magnetic-type of phono pickup may be used for playing records.

The 50B5 is a simple "electron-stream" modulated oscillator. The oscillator circuit is formed by the cathode, control grid, and plate which represent a three-element tube or triode. Its frequency of oscillation is determined by the resonant circuit formed by the grid winding and the variable condenser across it. The feedback winding of the oscillator coil is in the cathode circuit. Since the plate current also flows through the cathode circuit, this winding is the equivalent of the conventional plate circuit feedback winding. The feedback causes the signal to again appear at the grid for further amplification. Thus the signal is regenerated, and oscillations are maintained.

The screen grid (G2) of the 50B5 is in the path of the electrons moving from the cathode to the plate. Voltage variations applied to this grid cause corresponding changes in the flow of the electron stream. Thus the oscillator is electron-stream modulated by the 12AX7 voltage amplifier connected to it.

The two triodes in the 12AX7 tube are connected as a cascaded two-stage amplifier of very high gain. Audio output from the second stage is fed through a .02 mfd. condenser to the screen grid of the oscillator tube. This condenser blocks the flow of DC, but allows the audio signal to pass. Any crystal pickup or radio tuner has more than sufficient output to drive the grid (GT1) of



PICTORIAL DIAGRAM

Wireless Broadcaster

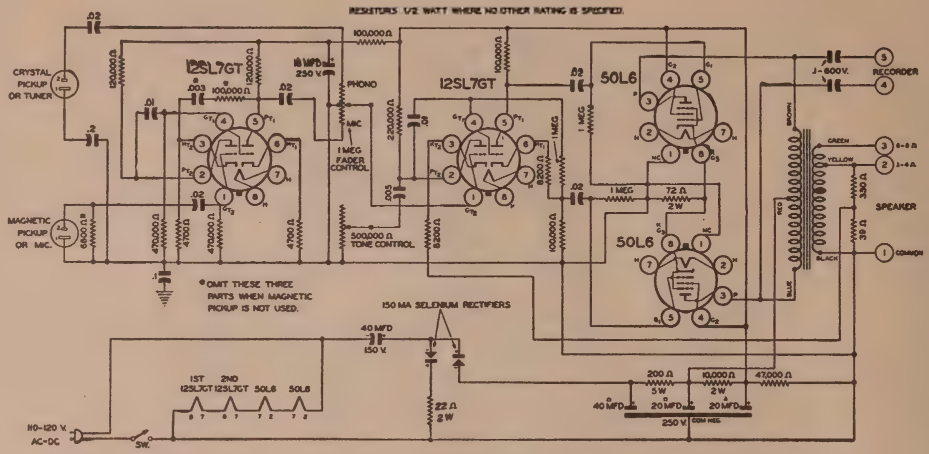
the second triode. The 3.3 megohm resistor (marked on the diagram) in series with the input of the grid circuit has an optional value that must be adjusted for proper modulation. Its value will depend on the voltage of the signal supplied at that point.

The first triode amplifier of the 12AX7 tube serves a dual purpose. The components that are starred (*) in the diagram must be included when a magnetic phono pickup is used. When these components are omitted from the circuit, this stage is a conventional high-gain amplifier for use with crystal or high-impedance magnetic microphones.

The starred (*) 8,200 ohm resistor is the proper "load" for the average magnetic phono pickup. A frequency selective, inverse feedback circuit is formed by the 510,000 ohm resistor and the .0003 mfd. condenser. Because the reactance of a condenser varies inversely with the frequency, more voltage is fed back from the plate of the second triode to the cathode of the first triode at higher frequencies than at the lower frequencies. The voltage fed back is out of phase with the signal voltage at the cathode and, therefore, reduces the amplification of the higher frequencies by the first triode. Thus, by proper choice of resistance and capacitance in this circuit, the proper bass boost is introduced. This is the type of equalization required for magnetic cartridges.

A 35W4 tube in a half-wave rectifier circuit is used for the power supply. The necessary filtering is obtained with a 20-20 mfd. electrolytic condenser and a 10,000 ohm resistor.

The antenna should be approximately 10 feet long for average use. If the oscillator is placed at a greater distance from the radio, additional length may be required. However, the antenna should be no longer than necessary to provide good results.



6 WATT AMPLIFIER
SCHEMATIC DIAGRAM

Six Watt Amplifier

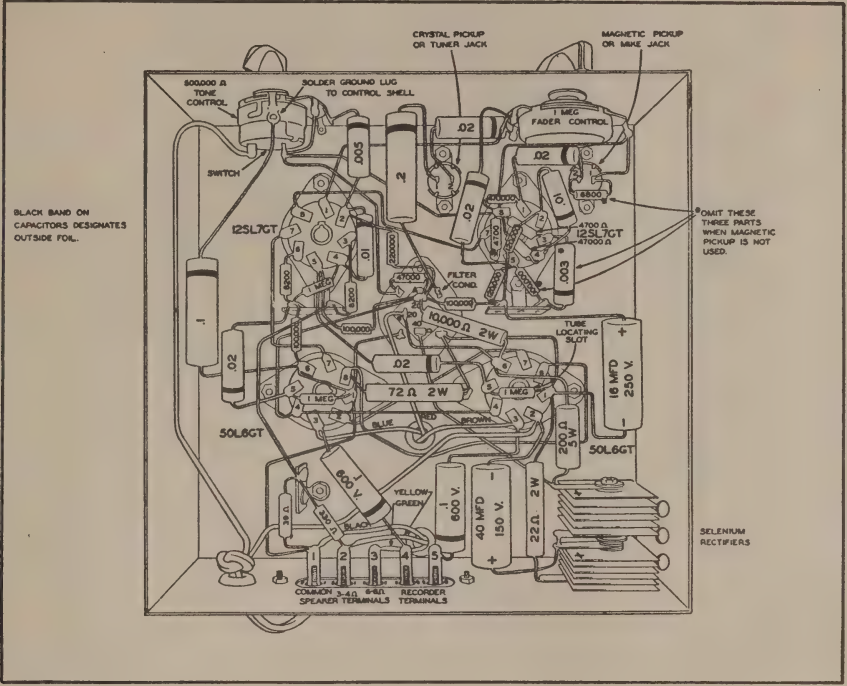
This amplifier is a highly versatile, yet compact unit, incorporating inverse feedback in the push-pull output, phase inversion, and a selenium power supply. It may be used for playing records, as a PA system with any high-impedance microphone, or as a recording amplifier. The amplifier also features equalization in the high-gain stage for use with a magnetic-type phono pickup.

A magnetic-type pickup is connected across the 6,800 ohm resistor in the input of the preamplifier or first section of the 12SL7GT. The starred (*) .003 mfd condenser and 100,000 ohm resistor form a frequency selective, inverse feedback circuit. Because a condenser has higher reactance to low frequencies than to high frequencies, more high frequency voltage is fed back from the plate of the second triode to the cathode of the first. This voltage is out of phase with the original voltage, which results in reduced amplification of the high frequencies. This is the type of equalization required for magnetic cartridges. By omitting the starred (*) components, this stage becomes a conventional high-gain amplifier for use with any crystal or high-impedance magnetic microphone.

A crystal pickup or radio tuner may be plugged into the jack which is connected to the fader control. This control permits fading from mike to phono.

Signals impressed on the grid of the first triode of the first 12SL7GT are amplified at the plate and passed on to the grid of the second triode in the same tube through the .01 condenser. After being amplified again, the signals are fed to the fader control. The other side of the fader control receives signals directly from the crystal pickup or tuner jack.

The first triode section of the second 12SL7GT amplifies the signal in the conventional way. The second triode section is a phase inverter, operating on a differ-



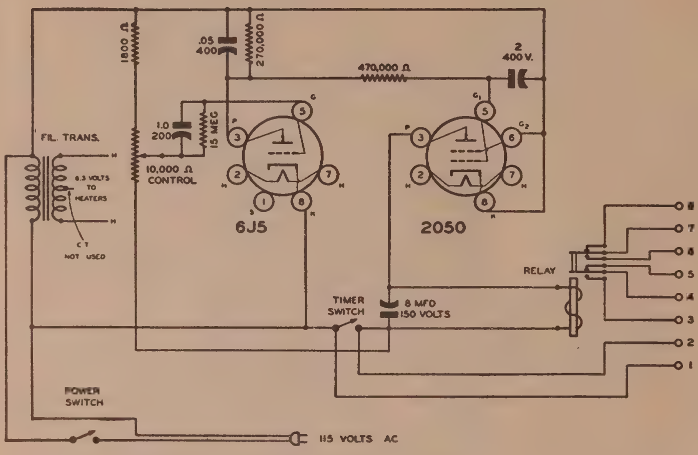
Six Watt Amplifier

ent principle from that shown in basic diagram No. 15. What would normally be a plate load resistor of about 200,000 ohms in the plate circuit of this tube is split between the plate and cathode. There is a 100,000 ohm resistor in both the cathode and plate circuits of this triode. Thus audio voltages appearing at these two points are equal in value, but out of phase from each other. These signals are passed on to the grids of the push-pull output stage.

The 50L6 tubes operate as a beam power push-pull stage. Their output connects to the primary of a center-tapped speaker-matching transformer. Proper impedance matching in the output transformer (matching the impedance of the speaker to the required impedance of the tubes in push-pull) is necessary if the full power output is to be secured at low distortion.

For the inverse feedback circuit the secondary of the output transformer has two resistors in series, acting as a voltage divider. A portion of the output voltage is fed back in series with the cathode of the first triode of the second 12SL7GT. This output voltage is out of phase with voltages appearing in this circuit and is in opposition to them. The out-of-phase voltage reduces any noise, hum, or distortion generated within the amplifier from this point on. Although inverse feedback reduces the overall gain of an amplifier, the benefits derived more than offset this factor.

The power supply employs two selenium rectifiers in a common-line voltage multiplier circuit. This circuit allows one side of the power line to be connected directly to the negative side of the filter output and thus overcomes the difficulty of a high-voltage difference between heater and cathode of the high-gain tubes at the end of the heater series string. By the abundant use of filtering capacity (the filter condenser is a triple-section unit having a total of 80 mfd) a filter choke is eliminated.



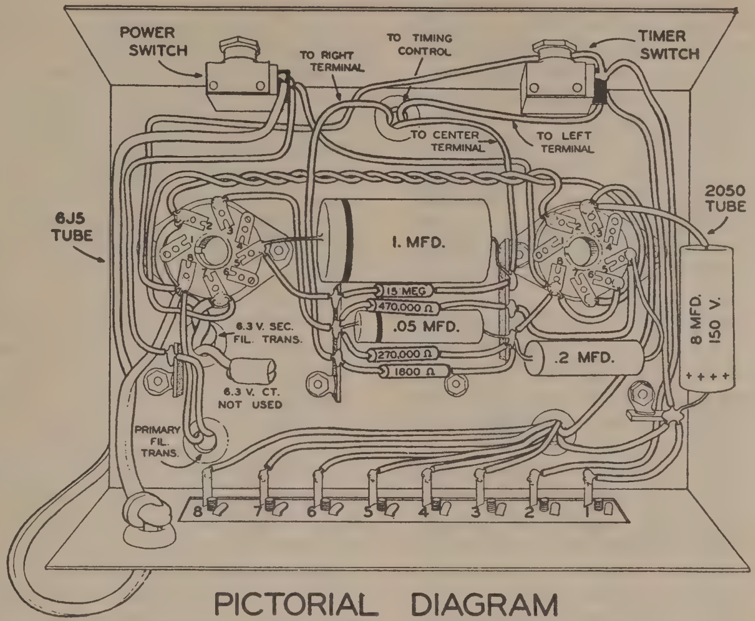
SCHEMATIC DIAGRAM
ELECTRONIC TIMER

Electronic Timer

Electronic Timers have found wide application in industry in recent years. The one shown here is highly efficient and provides a wide range of timing.

The 6J5 and 2050 tubes are "upside down" in relation to each other. That is, the plate of the 6J5 is on the same side of the line as the cathode of the 2050, and the plate of the latter feeds the cathode of the former. Thus the tubes are direct coupled to operate only in sequence. A change in the voltage applied to the cathode of the 6J5 results in a current increase from its plate, which is fed to the cathode and grid of the 2050 tube. The latter then operates and activates the relay which, in turn, controls such electrical devices as lights, small motors, etc. When a very heavy current is required for any electrical device, the relay may be used to operate an additional relay capable of handling the heavier load.

With the "Timer Switch" in the "Off" position, the cathode and grid of the 6J5 tube act as a diode which rectifies the AC current. A DC voltage results across the 15-megohm resistor and charges the 1 mfd. condenser to a peak of about 135 volts. In this position the potentials are negative on the grid side of the condenser and positive on the opposite side. When the "Timer Switch" is thrown to the "On" position, the 6J5 becomes a normal triode, but the grid is momentarily highly negative with respect to the cathode. This results in plate current cutoff. With no current flowing in the 270,000-ohm plate resistor, there is no voltage between grid and cathode of the 2050 thyratron tube. Under these conditions the thyratron tube will draw plate current and close the relay. In the grid circuit of the 6J5 the charge across the 1-mfd. condenser is slowly discharged through the 15-megohm resistor. In a few seconds the charge will have dropped to a value equal to the potential difference between the cathode and grid. When the condenser discharges to this point of



PICTORIAL DIAGRAM

Electronic Timer

balance, the 6J5 begins to draw current in the plate circuit, thus producing a voltage drop across the 270,000-ohm resistor. This same voltage drop also appears between grid and cathode of the 2050, stops the flow of plate current and allows the relay to open, ending the timing cycle. The "Timer Switch" must be reset before another cycle can be started.

The time cycle obtained depends upon the setting of the 10,000-ohm potentiometer, and the values of the resistor and condenser (in this case, 15 megohms and 1 mfd.) connected in parallel between the potentiometer rotor and the grid of the 6J5. Increasing the value of the resistor or condenser (or both) will increase the range of time. The maximum time cycle is obtained with the potentiometer arm at the bottom of the potentiometer (nearest the cathode side of the 6J5 tube). The variation of time obtained by the setting of the potentiometer dial is not directly proportionate with reference to the dial scale, but follows an exponential curve.

The type of relay used permits a variety of operations. Two independent units may be turned "on" or "off" for the duration of the timing cycle, or the contacts may be connected so that one unit is turned on while the other is turned off. The terminal strip may also be wired so that the timing cycle is started by a remote momentary contact switch.

This circuit will operate dependably on any line voltage from 100 to 130 volts AC. The .2-mfd. condenser between grid and cathode of the 2050 tube smooths out any line surges which may result from the use of heavy electrical equipment in industrial areas. Where line surges are not encountered the condenser may be omitted. The timer will then start faster when turned on. Plate voltage is obtained from the self-rectifying action of the tubes.

Ten Lab Projects

The Lab Projects were designed to show the relationship between different electronic units. They illustrate the fact that most circuits use the same basic components and that the difference between them lies in a few simple wiring changes.

The three tubes, 35Z5GT, 35L6GT, and 12SF5GT are connected in series and use a total heater voltage of 82 volts, which is supplied by the secondary of the power transformer. Although certain of the units do not use the electronic functions of all of the tubes, the tube filaments are always wired in the circuit to balance the 82 volts supplied by the transformer.

In many cases comparison of a pictorial diagram with a schematic will show that some tube terminals connected in the pictorial are not connected to any tube element in the schematic. These terminals are used only as convenient tie points to eliminate splicing of wires.

The coil of the relay in some units performs the functions of a filter choke. When it is used as a relay, both sections of the dual 20-mfd. condenser are connected together, making it equivalent to a single 40-mfd. filter condenser.

Project 1 is a Regenerative Receiver, capable of operating a loudspeaker on powerful local stations. The potentiometer is used as a regeneration control, and the relay acts as a filter choke. Loudspeaker operation requires the addition of an output transformer. A good antenna and ground must also be added.

Project 2 is an Audio Amplifier which can be used for microphone or phono pickup operation. The 10,000-ohm resistor, when wired into the circuit from B+ to the mike terminal, supplies the necessary DC voltage to operate a high-resistance carbon microphone.

Project 3. The Phono Oscillator is actually a low-powered transmitting unit and does not have to be connected to a radio set. The carrier signal transmitted by the unit is modulated by the voltages generated by a phono pickup. This signal is received by the radio set in the same manner as a regular broadcast signal.

Project 4. The Broadcast Station uses the same circuit as the phono oscillator except for the 10,000-ohm resistor required in the mike current supply circuit. The resistor is used in the same location as in the audio amplifier (Project 2). The carrier signal is then modulated by the microphone action, and the radio receiver "picks up" the signal and converts it to sound.

Project 5. In the Code Practice Oscillator the condenser-resistor network in the grid of the 12SF5GT tube causes oscillations at two frequencies, one at RF and one at AF. The RF is self-modulated by its own audio signal, and a tone is produced for code practice use. This tone may be heard directly by connecting headphones to "PHONES" terminals, or picked up in one or more radio sets.

Project 6. The Capacity-Operated Relay is an oscillator which draws only a small amount of plate current, insufficient in value to close the relay. When the pickup wire is touched, the body acts as additional antenna and loads the oscillator, resulting in a current increase that closes the relay and permits it to operate a warning bell, lights, etc.

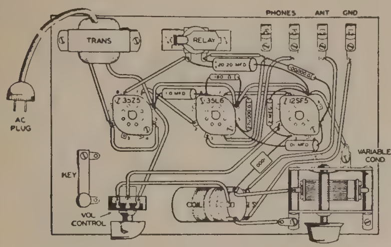
Project 7. In the Signal Tracer the 12SF5GT is a detector, and the 35L6GT is an amplifier. With test probes from the signal tracer applied to any point in a radio circuit, the RF or IF signal received is demodulated, and the remaining audio signal is amplified and heard in headphones connected to the signal tracer. Thus, by progressive checking, the point of failure can be located.

Project 8. In the Electronic Timer, when the switch is open, the 0.5-mfd. condenser is charged to a high voltage which is applied to the grid of the 12SF5GT. This results in plate current cutoff. Closing the switch discharges the condenser through the 10-meg. resistor, thus reducing the negative potential at the grid of the 12SF5 until a point is reached when plate current flows and activates the relay. The time cycle depends on the setting of the 10,000-ohm potentiometer. Like the timing circuit on page 26, the time cycle is not affected by line voltage variations.

Project 9. In the Electronic Switch Circuit the 10,000-ohm potentiometer is adjusted so that the cathode of the 35L6GT is made positive with respect to the grid. This prevents the flow of current through the tube and keeps the relay open. A short at the switch terminals reduces the cathode to grid difference and permits passage of the current required to operate the relay.

Project 10. The Phototube Relay (not illustrated) operates on the same principle as the electronic switch. In this case, however, light falling on the photo-cell causes current to flow, reduces the difference in cathode to grid voltages and permits passage of the current required to activate the relay.

Ten Lab Projects



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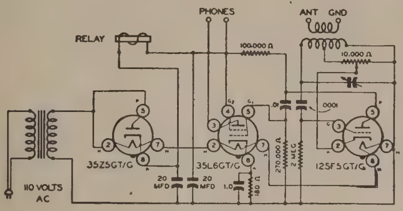
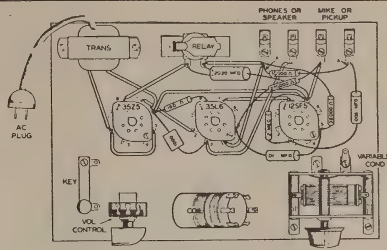


SCHEMATIC DIAGRAM
BROADCAST RECEIVER



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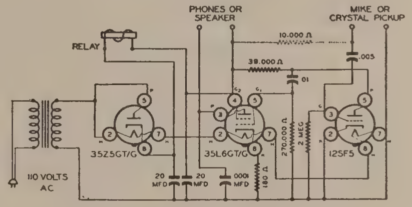
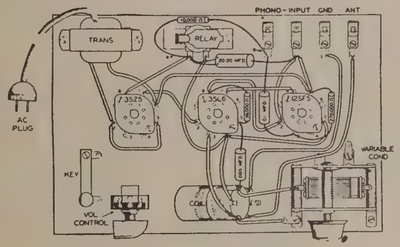


SCHEMATIC DIAGRAM
AUDIO AMPLIFIER



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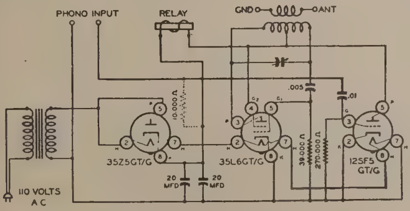
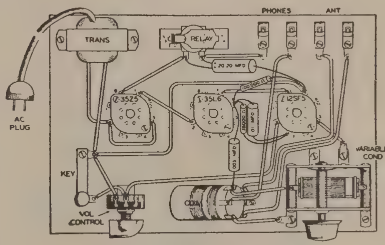


SCHEMATIC DIAGRAM
BROADCAST STATION OR PHONO OSCILLATOR



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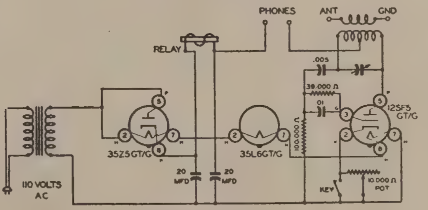
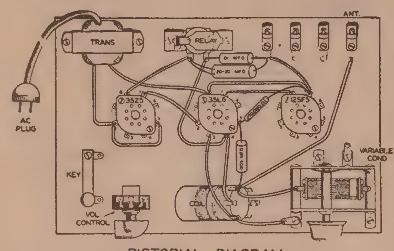


SCHEMATIC DIAGRAM
CODE PRACTICE OSCILLATOR

Ten Lab Projects



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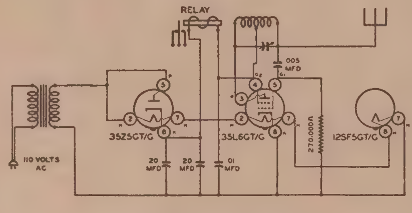
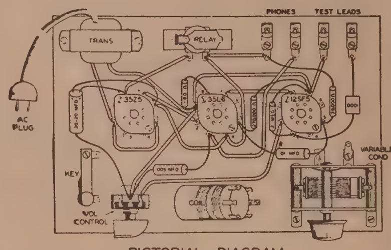


SCHEMATIC DIAGRAM
CAPACITY OPERATED RELAY



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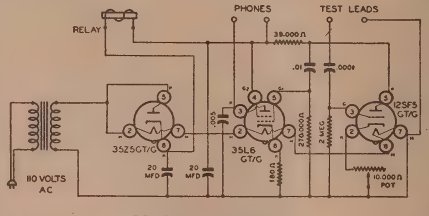
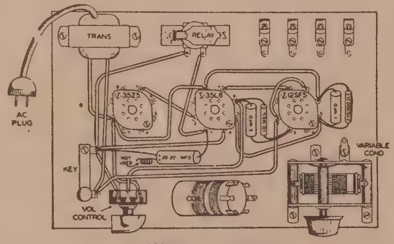


SCHEMATIC DIAGRAM
SIGNAL TRACER



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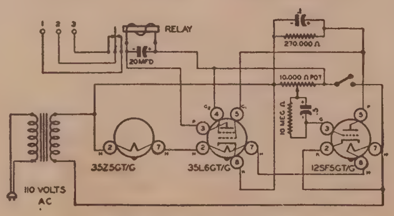
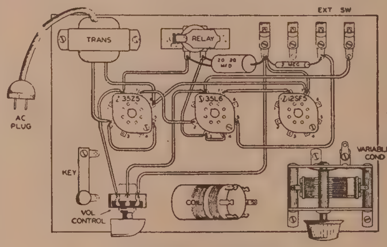


SCHEMATIC DIAGRAM
ELECTRONIC TIMER



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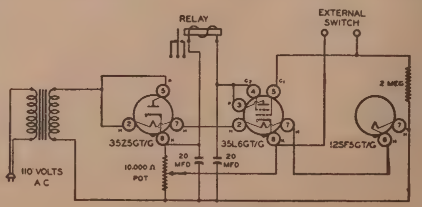
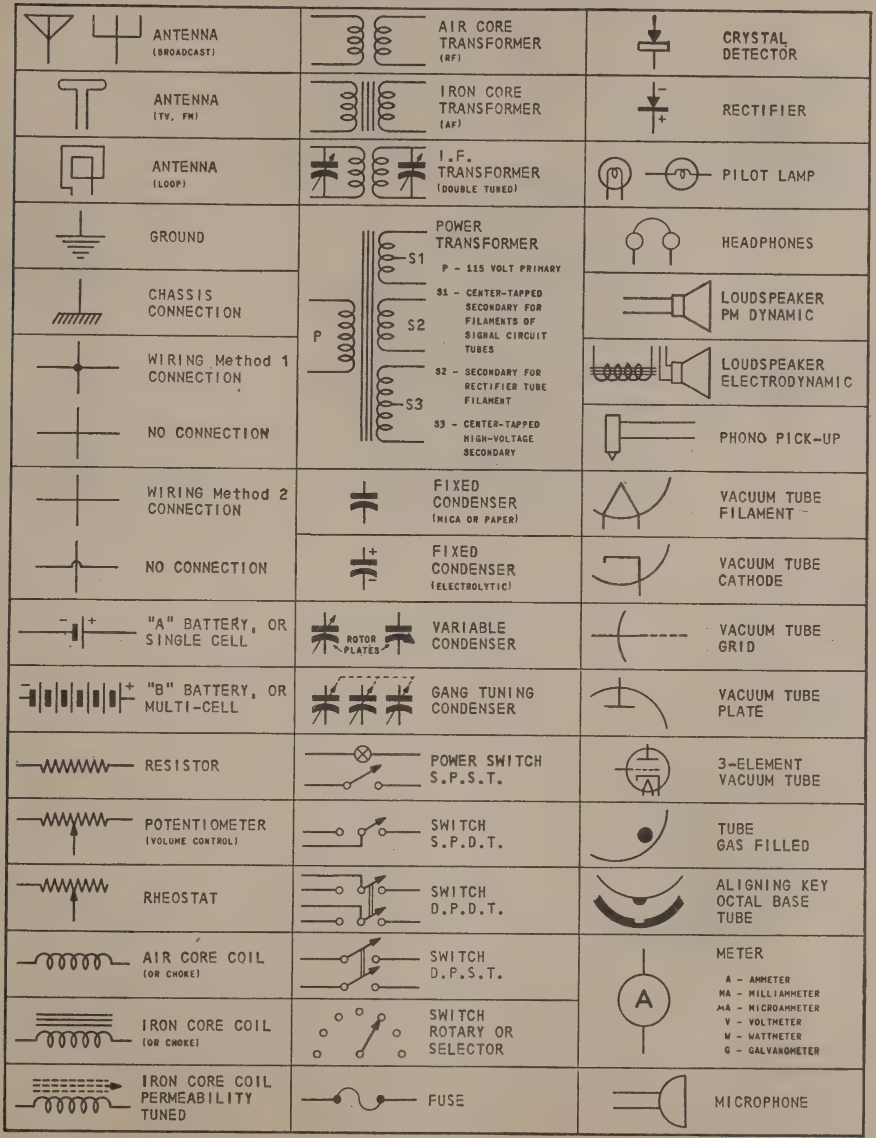


SCHEMATIC DIAGRAM
ELECTRONIC SWITCH

Schematic Symbols Used in Radio



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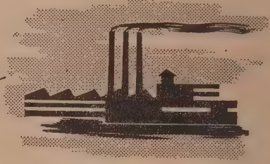
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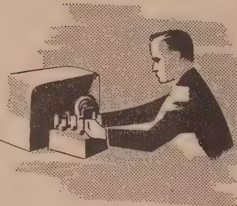
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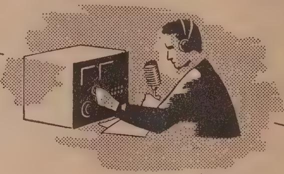
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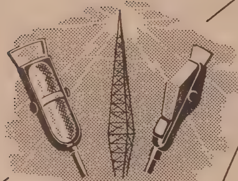
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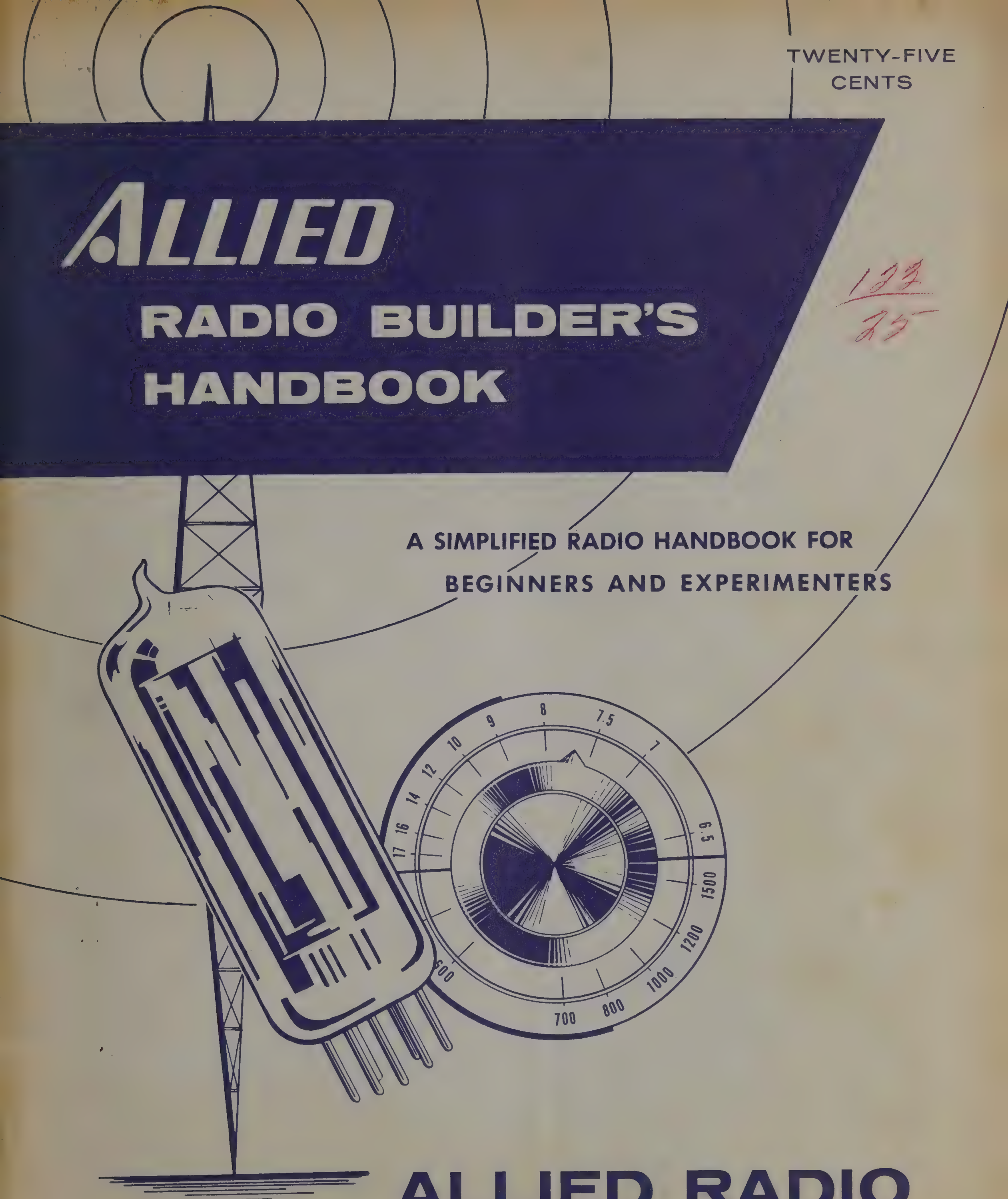

ALLIED RADIO

100 N. WESTERN AVENUE CHICAGO 80, ILLINOIS

ALLIED'S
RADIO BUILDER'S
HANDBOOK

FIFTH EDITION

Fourth Printing May, 1961

A SIMPLIFIED RADIO HANDBOOK FOR
BEGINNERS AND EXPERIMENTERS

PUBLISHED BY

ALLIED RADIO CORPORATION

CHICAGO

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FOREWORD

THE *primary purpose of this book is to acquaint those who are just getting started in radio and electronics with the basic principles and techniques employed in circuit building. The fundamentals are described in easy-to-understand language, without the use of mathematics and formulas. With the aid of this book, you can actually learn by "doing"; by assembling your own equipment piece by piece.*

The circuits listed in this handbook have been carefully selected by our Technical Staff and Educational Division to aid your progress in learning to build radio and electronic equipment. All are tried and proven; the result of Allied's years of experience in dealing with radio students, instructors, experimenters, and engineers.

The method of presentation was especially planned to make this book a useful text for the classroom and for home study, as well as a reliable guide for self-teaching.

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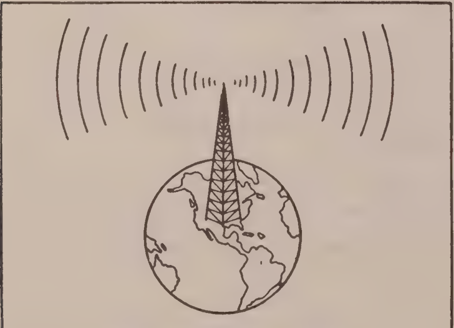
How Radio Earned Its Place In The Sun

When Guglielmo Marconi finally succeeded in 1895 in transmitting a "wireless" message over a distance of a mile and a half, he set in motion a chain of development that has revolutionized the art of communication. Marconi did not "invent" radio nor was he alone in the early work in this new art. Yet from that small beginning, radio has steadily advanced to the point where today its influence is felt in every phase of our lives. Today, radio provides communications facilities across continents and oceans; saves lives on sea and on land; aids police authorities in enforcing the law; transmits news dispatches to the daily press; and guides airplanes along the skyways. Radio was the forerunner of radar, which permits interception of enemy planes hundreds of miles away; of naval gun-laying equipment which permits deadly accurate fire upon surface vessels out of sight range, beyond the horizon; of proximity-fuse missiles, which explode when within a pre-determined range of the target; of guided missiles, whose trajectory can be altered by remote control.

In the field of entertainment and education, radio has brought to us the leaders of the world in drama, music, literature, art, science and politics. It has brought to us the modern miracle of television. Through this remarkable medium, the world's greatest entertainers virtually step into your living room; you become a spectator at every kind of sports event; you see history-making public events from the comfort of your own home. The full impact of television upon our lives cannot be measured by those of us living in this thrilling period of its development. Historians of the future will be able to assess the far-reaching effects of television upon the development of modern society.


Radio has made the world smaller.

Yes, after many years of perseverance against countless obstacles, of unstinted toil by thousands of people in the vanguard of science — radio has earned its place in the sun. For radio has proved itself to be the greatest force in the twentieth century for bringing knowledge, pleasure and joy to all mankind.

Radio Is A Fascinating Hobby Easy To Learn

The average radio listener regards radio as a deep mystery. But radio need not be a dark mystery. To thousands of government-licensed Amateurs and to multitudes of experimenters and radio builders, radio is a fascinating hobby that gives endless hours of real thrills, a vast store of useful knowledge, and the deep satisfaction of knowing that the radio equipment one has built himself will really work.

To you, therefore, who are interested in the science of radio—in learning how to build practical radio circuits, in understanding some of the fundamentals of radio—this book is addressed. We have not attempted to make this an exhaustive complicated treatise. We think that you will get more real help by covering thoroughly only those basic details and practical applications that will be of use to you. Our aim, in short, has been to give you a good working knowledge of radio building and experimentation, and to set you on the right path toward more advanced work.

A word of advice: study each section thoroughly before going on to the next section.

What Is A Radio Signal?

Before going any further, let's take a quick glance at the overall picture of a radio signal being transmitted from a broadcast studio to your home.

A "Signal" is any intelligence that we wish to transmit. Suppose we wish to transmit music. The variations in frequency (pitch) and intensity (loudness) of the music — comprise the signal. If we transmit this signal by the standard AM (amplitude-modulation) broadcast system, this is what happens:

In the studio, the sound waves produced by the music cause vibrations of a diaphragm in the microphone. From this point on, until the music is reproduced in your home, the form of this signal changes; it may be a current wave, an electromagnetic wave, a voltage wave, etc. However, in every case, the character of the signal is scrupulously preserved. In other words, the variations in current, voltage, etc. correspond to the variations of the music in the studio. Thus, the received signal (ideally) is an exact duplicate of the transmitted signal.

The varying currents from the microphone are known as "audio frequency" (AF) impulses. These are amplified millions of times, and then super-imposed on a powerful "radio frequency" (RF) current known as the "carrier." RF waves are much shorter than AF waves, and will travel great distances through space—whereas the AF waves will not.

We now have a "modulated carrier." The energy in this carrier is transmitted through space (in all directions) by electromagnetic and electrostatic fields, generated by the high-frequency currents fed into the transmitting antenna. Many thousands of watts of energy is radiated, but most of it is lost in space; only a very small portion of it (a few millionths of a volt) reaches the antenna of your receiver at home.

This feeble signal is picked up by your radio receiver's antenna, amplified many times, and is then converted back to audio impulses. After further amplification, these impulses are fed into your headphones or loudspeaker, where vibrations are produced, creating sound waves which correspond to the sound waves in the studio, where the signal originated.

All this happens in a fraction of a second. With the speed of RF waves at 186,000 miles a second, you can readily see how quickly this takes place. Actually you hear the broadcast program from your radio before the audience hears it in the studio. This is because sound waves travel through the air at the rate of only 1,086 feet per second as compared with the speed of radio waves.

Other Kinds Of Transmission

In addition to the amplitude-modulation method of transmission, there are other types: Code (Continuous Wave or CW), for sending messages; Frequency Modulation, for noise-free sound, and Television.

Code (CW)

Code transmitters do not require audio. The carrier is broken into dots and dashes by means of a telegraph key and relays. It is heard in the receiver (if of the regenerative type or superheterodyne with beat frequency oscillator) as an intermittent tone or whistle. Another less common type of code transmission does make use of a modulator. In this method a "tone oscillator" is keyed.

Frequency Modulation (FM)

In frequency modulation, as the name implies, the frequency of the carrier is changed—above and below the mean frequency. Amplitude remains constant. The main advantage of FM over AM is a high degree of noise reduction at the receiver. This is possible because all noises in the radio spectrum are RF oscillations which vary in amplitude, and the FM receiver does not respond to amplitude variations.

Television (TV)

Television requires transmission of two signals: the audio signal and the video (picture) signal. The audio is an FM signal; the video is an AM signal. Both RF carriers are transmitted at the same time. At the receiver, these signals are amplified, detected, and fed to the speaker and picture tube, respectively. Television also requires transmission of special synchronizing ("sync") and blanking pulses. The sync pulses coordinate the picture-tracing on the face of the picture tube with the scanning of the subject in the TV studio. The blanking pulses blank out the picture tube during the short retrace periods of the horizontal and vertical "sweep" oscillators. Thus the television signal is extremely complex, and requires a receiver more complex than any FM or AM set.

In both FM and TV, the RF carrier frequencies are much higher than on AM. Such high frequencies are limited in range, because they travel in a straight line and do not follow the curvature of the earth, as do the longer waves (lower frequencies) used in standard AM broadcasting. Therefore, during average conditions, the transmission radius is 50-150 miles.

The Experimenter-Builder And What He Does

No matter how far radio progresses, there will always be a place for the experimenter-builder. He is the fellow who tries out new circuit designs and new gadgets. Sometimes he stumbles across a new idea that is of distinct value to radio manufacturers. Sometimes he plans a career for himself as a radio engineer or a servicing expert. Sometimes he decides to make radio a hobby, becomes an Amateur and goes on the air with his own transmitter.

However, generally the experimenter-builder is a "fan." He is in radio because he likes it—because he likes to build his own sets, experiment with circuit layouts, and try to improve the results he gets. But whatever *your* reason for taking up radio and whatever the facilities you have available for work, you will get as much out of your hobby as you put into it. If, some day, you can turn your hobby into your profession, all the better. But even if your interest in radio remains a hobby you will get from it the advantages of acquiring some mechanical skill, learning to use tools properly, joining a wide fellowship of friendly men and boys, developing your ingenuity, and doing constructive work.

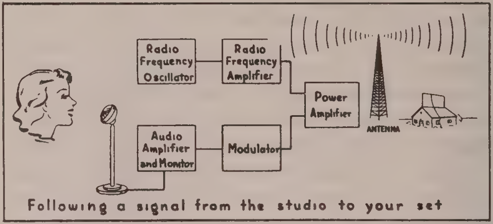
Radio need not be an expensive hobby. The tools required for the beginner are few and inexpensive. And parts used in building any one circuit can almost always be used again in many other circuits.

Getting A Start In Radio Building

For the average radio newcomer, the best way to learn radio is by "doing." Do you remember how you learned to play baseball, or to drive a car, or to do any one of a hundred different things that require a development of skill? Not all the explanations in the world seemed of much use until you had actually tried out these methods yourself. Not until you had actually experienced playing baseball or driving a car, did you begin to see how different the job really was from what it had sounded like.

Now, in the same way you can learn radio by doing simple but effective practical work, by putting the knowledge you gain to actual use, and by working up gradually to more advanced material.

By building a simple radio set from a circuit diagram, you will become familiar with basic radio parts and their functions, with set layout and construction, with the meaning of the various radio symbols, and with some of the fundamental ideas behind radio design. You will develop a feeling of real achievement when you find that the first simple set you build will actually work. And, finally, you will bring an intelligent understanding to your work when you approach the more difficult phases of radio.


Radio Frequency Oscillator
Radio Frequency Amplifier
Power Amplifier
ANTENNA
Audio Amplifier and Monitor
Modulator
Following a signal from the studio to your set

The audio signal leaves the microphone, is amplified in the AF amplifier stages, and then fed into the final transmitter stage, the RF power amplifier. There it is superimposed on the RF carrier wave. It is then fed into the transmitting antenna, which radiates the carrier into space.

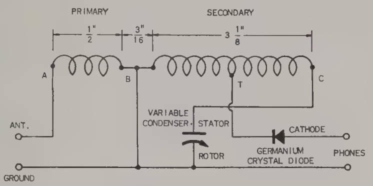
Accordingly, in our discussion, we shall keep uppermost in our minds the needs of the radio newcomer whose first goal is to build a radio set that will work. We shall discuss the tools and materials you will need. We shall find out the most efficient way of putting a radio set together. And we shall introduce whatever theoretical knowledge you need as you need it—and when you are ready for it.

What Kind Of Set Should Be Built First?

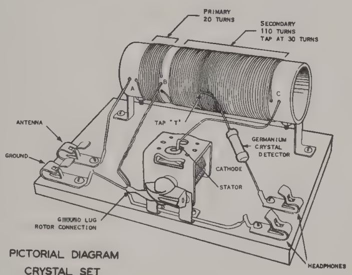
Since the crystal set is the simplest of all receivers, it is a good idea to build one as your first step on the road to radio skill. A crystal set offers several advantages to the beginner. It requires only a few inexpensive components, very simple wiring, uses no power, and operates indefinitely. The diagrams on the following page show just how simple it is to build. The set described in these diagrams is available in kit form at Allied. The kit includes a fixed-type germanium crystal, permanently adjusted to the most sensitive point.

Best results are obtained when using a good high antenna of fifty feet or longer; the ground connection can be made to a cold water pipe. Headphones used should have an impedance of 1000 ohms or greater. Headphones and antenna, available as accessories, are also listed in the Allied catalog.

knight CRYSTAL SET KIT



SCHEMATIC DIAGRAM
CRYSTAL SET


PRIMARY 20 TURNS
SECONDARY 110 TURNS TAP AT 30 TURNS
A
B
C
ANTENNA
GROUND
TAP "T"
GERMANIUM CRYSTAL DETECTOR
CATHODE
STATOR
GROUND LUG ROTOR CONNECTION
HEADPHONES

PICTORIAL DIAGRAM
CRYSTAL SET

What Next?

Crystal sets detect signals without providing any amplification. For this reason, they do not have enough sensitivity to receive really weak stations. The Knight-Kit "Span Master" 4-Band Regenerative Receiver Kit which is described on pages 36 and 37 of this book has sufficient sensitivity to receive standard broadcast stations from all over the country, as well as foreign and domestic shortwave stations. The "Span Master" receiver makes an excellent and worthwhile project after completing assembly of the crystal set.

The construction of a modern superheterodyne broadcast receiver should be quick and easy for anyone who has gained some wiring and soldering experience. The Knight-Kit 12-In-1 Electronic Lab Kit described on pages 33-35 is an excellent training kit. When you are ready to build a superhet, you'll find the Knight-Kit "Ranger III" described on pages 38 and 39 an up-to-the-minute set, worthy of consideration.

The electronic lab kit mentioned above permits building any one of 12 interesting electronic gadgets, including a simple regenerative standard broadcast receiver. This kit offers a very wide scope of experience and certainly warrants consideration by the beginner.

The Radio Spectrum

The table below covers only the major portion of the radio spectrum. Above 545 meters, there are weather report and time signal stations, aircraft beacons, and some foreign long-wave stations. Below 10 meters, there are Television, FM, Aircraft, Amateur and Police Stations.

The tuning range of Short Wave sets varies according to the range of the coils used. Usually, this range is from about 9.5 to about 217 meters, and covers Amateur stations, police calls, ships-at-sea, airplane calls, commercial radiophone transmission, and foreign Short Wave stations.

Kilocycles	*Meters*	*Types of Stations and General Characteristics*
550 to 1500	545 to 200	BROADCAST BAND—Local standard broadcast stations. Cross-country reception during ing evening and early morning hours.
1500 to 5770	200 to 52	INTERMEDIATE SHORT WAVE BAND—Police, Amateurs, aircraft, foreign broadcasting stations. Best reception during evening and early morning hours.
5770 to 30,000	52 to 10	SHORT WAVE BAND—Amateurs, foreign broadcasting stations, commercial telegraph, ships-at-sea. Best reception during daylight hours.

In the above table, the frequency of each band is given in kilocycles. This is a common practice below 10,000 kilocycles. However, above this figure, the numbers tend to become cumbersome and the larger unit of megacycles is used. 1 megacycle is equal to 1,000,000 cycles whereas 1 kilocycle is equal to 1,000 cycles. Thus, 10,000 kilocycles are equal to 10 megacycles, 20,000 kilocycles are equal to 20 megacycles, etc.

Types Of Circuits

The chief characteristics to be looked for in any radio set are: selectivity (ability to separate stations); sensitivity (ability to pick up weak signals); stability (ability to stay dependably tuned to a signal); and fidelity (ability to reproduce exactly what is put on the air from the transmitter).

The most selective type of circuit is the Superheterodyne. It provides, in greatest measure, all the desirable characteristics in radio.

The Tuned Radio Frequency (T.R.F.) circuit is one in which R.F. amplifier circuits are tuned to the desired frequency by varying inductance or capacity. This circuit offers good fidelity, but is less selective than the superhet.

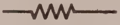
The Regenerative circuit is the third chief type. In such a circuit, in effect, sensitivity is greatly increased by returning some of the amplified signal for still more amplification. A regenerative-type circuit is less selective than a superhet. For the purposes of the beginner, the Regenerative circuit is probably the best because it is easiest to wire, most inexpensive insofar as parts are required, and selective and sensitive enough for ordinary use.

How To Read Schematic Diagrams

Now, if you have already turned ahead to look at the diagrams in the latter portion of this book, you will have seen that they consist of numerous symbols, lines, circles, and arrows, with occasional labels in words or letters. Let us see why radio circuits must be represented in terms of such symbols.

In the first place, you will agree that some sort of diagram or blueprint is necessary as a basis for construction work. The function of such a diagram is, of course, the same as that of any blueprint used in constructing a desk, a table, a ship model, or a house. You want to know just how every part fits together. You want to have an accurate guide to follow.

The circuits described in detail later on are shown in both pictorial and schematic forms. Pictorial diagrams are the easiest to follow and enable you to quickly determine the layout of all parts. Since pictorial diagrams require a great deal of effort and the skill of an artist to make, they are seldom used. Instead, most magazine construction articles, most radio handbooks, and even beginners' manuals employ what are known as schematic diagrams.

The symbols used in schematic diagrams are explained in the chart on the next page. These symbols are merely a kind of shorthand to represent component parts. Instead of showing a picture of a fixed resistor every time this part is used in a circuit, we employ the corresponding symbol, . This symbol always means a fixed resistor. If you will turn ahead to one of the diagrams at the back of this book, you will easily be able to pick out the portions of the circuit in which a fixed resistor is used.

Again, instead of drawing a picture of a capacitor we use the symbol ; or, for a variable capacitor ; and so on. Examine the chart of symbol explanations shown on page 10. Once you understand the meanings of the symbols, radio circuit diagrams will no longer seem mysterious to you. You might also refer to your Allied catalog to see what the actual items look like.

Since you will frequently find it necessary to use symbols in drawing circuits by yourself it is also advisable for you to obtain practice in drawing these symbols as well as in recognizing them. It is suggested that you first learn how to draw the individual symbols—memorizing them as you draw them. After a time, you will find it beneficial to copy an entire diagram so that you can gain proficiency in arranging the elements in a diagram. After sufficient practice, you ought to be able to draw simple diagrams from memory.

When constructing a unit from a diagram, always work systematically. Read the diagram step by step, checking off each part, wire and connection as it is installed. Mount parts in logical sequence, so that those connnected first will not interfere with installation of the rest.

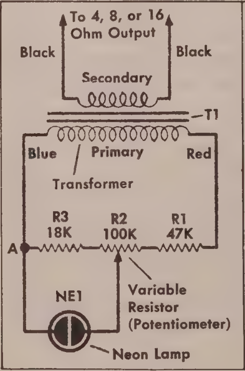


Figure 1. A simple schematic diagram.

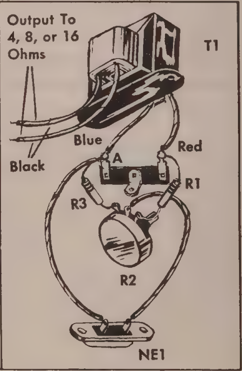


Figure 2. Pictorial diagram of the circuit of Figure 1.

An illustration of a schematic diagram and its associated pictorial counterpart is shown in Figs. 1 and 2. Let us consider Fig. 1 first. This circuit contains a transformer, three resistors of which one is variable, and a neon bulb. The three resistors are connected so that one fixed resistor attaches to one side of the variable resistor and the other fixed resistor attaches to the other side. This combination is then hung across one transformer winding, the side with the red and blue wires. Finally, the neon bulb is connected across the 18,000-ohm resistor.

Now compare the schematic diagram of this circuit with the pictorial diagram in Fig. 2. A good place to start is with the red and blue wires coming from the transformer. The blue wire connects to a soldering lug on a small terminal strip. One side of the neon bulb goes to the same lug, as well as one wire from the 18,000-ohm resistor. At this point the three wires would be soldered together. To identify this point in the pictorial diagram with the same point in the schematic diagram, both have the letter A.

We might stop here and note that the small terminal strip is found only in the pictorial diagram; it does not appear in the schematic diagram. This is because this component is not necessary to the circuit. Rather, it is a convenience item designed to make it easier to wire several parts together. We could take the three wires from the transformer, the neon bulb, and the 18,000-ohm resistor and simply twist them together in mid-air and obtain the connection that way. However, this is not a secure way of wiring a circuit. Much more desirable is a rigid point, such as a terminal lug, to which all three wires can be solidly attached. Such tie points are quite common and found in all but the simplest circuits. Note, however, that they seldom appear on the schematic diagram.

Incidentally, another item not shown in the schematic diagram is the chassis on which all the parts are mounted. However, a chassis is always used and so this is understood.

The second lug on the terminal strip in Fig. 2 holds the red wire from the transformer and one end of resistor R1. The other end of R1 attaches to one end terminal of variable resistor, R2. The other end terminal of R2 has the unattached lead from R3 connected to it. This still leaves the center terminal of R2 free and if we carefully examine the schematic diagram of this circuit, we note that one wire from the neon bulb goes here. With this final connection, the circuit wiring is complete.

While the foregoing deals with a very simple circuit, it covers all the elements of wiring that any other circuit, simple or complex, would follow. The only significant difference would be the number of connections that would have to be made.

Some Theoretical Background

At this point we shall take time to discuss, briefly, some of the theoretical considerations which underlie the whole science of radio. We shall not go into too great detail, but we shall describe radio theory to the extent necessary for your purpose as a radio-builder.

To begin with, radio and electricity are both branches of the science of Physics, which the dictionary defines as:

> The science that treats of the phenomena associated with matter in general, especially its relations to energy, and of the laws governing these phenomena, excluding the special laws and phenomena peculiar to living matter (biology) or to special kinds of matter (chemistry). Physics is generally held to treat of (1) the constitution and properties of matter, (2) mechanics, (3) acoustics, (4) heat, (5) optics, and (6) electricity and magnetism.

The force of electricity plays a leading role in making possible the whole range of radio transmission and reception. In the first place, your home radio depends on the electrical power line or on batteries (which are reservoirs of electrical power) for operating current. This electrical power may be changed in form and increased or decreased in voltage (electrical pressure) before it is made to serve the circuit. In the second place, besides this external electrical energy, the incoming electro-magnetic waves striking the antenna of your radio produce minute but definite electrical currents in the input circuits of the radio receiver.

Electricity itself is a mysterious agent made to serve our needs in many ways. While we are able to control and use this energy quite safely, we really do not know exactly what it is. Over a period of years, however, scientists have been able to devise a useful theory which fits all the facts and is now generally accepted.

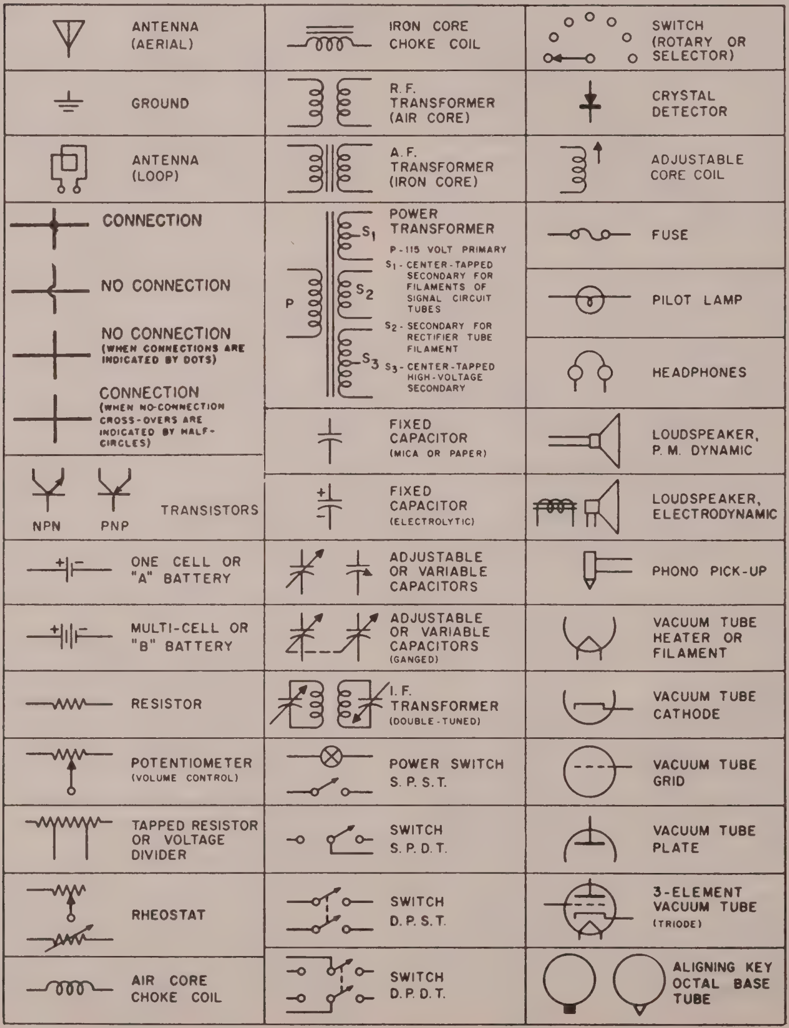
The Electron Theory

Briefly, this theory might be summarized somewhat as follows: All matter in the world is made up of about 100 fundamental materials called elements. These include such familiar elements as oxygen, hydrogen, carbon, gold, etc., and some rare substances known as radium, tungsten, yttrium, helium, etc. A combination of these elements yields other

SCHEMATIC SYMBOLS USED IN RADIO

The symbols below are standard in radio, TV and electronics diagrams. Popular components are represented. An industry-wide attempt is being made to standardize schematic diagrams. All current diagrams will be enough like these to easily identify the components. Note the two methods used to indicate a wire connection and a crossover. Both are in common use, but the curved wire crossover and dotted connection is preferred.

The symbol for a ground point may indicate an actual connection to the metal chassis, or a connection to a common lead, usually the B– voltage point. All ground points may usually be assumed to be connected together electrically.


ANTENNA (AERIAL)
GROUND
ANTENNA (LOOP)
CONNECTION
NO CONNECTION
NO CONNECTION (WHEN CONNECTIONS ARE INDICATED BY DOTS)
CONNECTION (WHEN NO-CONNECTION CROSS-OVERS ARE INDICATED BY HALF-CIRCLES)
NPN
PNP
TRANSISTORS
ONE CELL OR "A" BATTERY
MULTI-CELL OR "B" BATTERY
RESISTOR
POTENTIOMETER (VOLUME CONTROL)
TAPPED RESISTOR OR VOLTAGE DIVIDER
RHEOSTAT
AIR CORE CHOKE COIL
IRON CORE CHOKE COIL
R.F. TRANSFORMER (AIR CORE)
A.F. TRANSFORMER (IRON CORE)
S1
S2
S3
P
POWER TRANSFORMER
P - 115 VOLT PRIMARY
S1 - CENTER-TAPPED SECONDARY FOR FILAMENTS OF SIGNAL CIRCUIT TUBES
S2 - SECONDARY FOR RECTIFIER TUBE FILAMENT
S3 - CENTER-TAPPED HIGH-VOLTAGE SECONDARY
FIXED CAPACITOR (MICA OR PAPER)
+
-
FIXED CAPACITOR (ELECTROLYTIC)
ADJUSTABLE OR VARIABLE CAPACITORS
ADJUSTABLE OR VARIABLE CAPACITORS (GANGED)
I. F. TRANSFORMER (DOUBLE-TUNED)
POWER SWITCH S. P. S. T.
SWITCH S. P. D. T.
SWITCH D. P. S. T.
SWITCH D. P. D. T.
SWITCH (ROTARY OR SELECTOR)
CRYSTAL DETECTOR
ADJUSTABLE CORE COIL
FUSE
PILOT LAMP
HEADPHONES
LOUDSPEAKER, P. M. DYNAMIC
LOUDSPEAKER, ELECTRODYNAMIC
PHONO PICK-UP
VACUUM TUBE HEATER OR FILAMENT
VACUUM TUBE CATHODE
VACUUM TUBE GRID
VACUUM TUBE PLATE
3-ELEMENT VACUUM TUBE (TRIODE)
ALIGNING KEY OCTAL BASE TUBE

substances; for example, hydrogen and oxygen, combined in proper proportions, result in water. The elements themselves are composed of a number of atoms. No one has ever seen an atom, since even the most powerful microscope cannot magnify an atom sufficiently to make it visible.

If an atom could be isolated, however, we should find, according to modern theory, that it is made of a central body of positively charged electricity consisting of a number of protons, surrounding which are bodies of negatively charged electricity called electrons. The opposing electrical forces in the proton and electron serve to keep the atom united. Electrons and protons are the same in all atoms. The difference between atoms lies in the number of electrons and protons which make up the atom and in the method of their combination.

Each electron, of course, is very small, and millions upon millions are required to form the current used to heat the filament of a single radio tube.

Electrons exist everywhere in nature and free electrons tend to be present in equal numbers in all places. If a body has more electrons than surrounding bodies it is negatively charged. But if a body lacks sufficient electrons to be neutral, it will be positively charged. Now, if a positively charged body is brought into contact with a negative body, there will be a flow of electrons from the negative to the positive (see Fig. 3) until both bodies will become neutral (that is, both will have an equal number of electrons). In short, electrons, being negative in potential, are always attracted to a positively charged body.

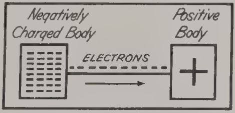


Figure 3. Diagram shows flow of electrons.

The charged bodies need not be brought into direct contact for the electrons to flow—a wire which acts as a conductor may be used instead. Practically all metals are good conductors of electricity. Silver is the best, but since it is too expensive for ordinary use, the next best conductor, copper, is widely used.

Resistance

Any conductor, however, has a certain amount of opposing force to the passage of electrons. This opposition is known as resistance. Silver or copper wire has very little resistance (which is why copper is so extensively used for carrying electrical current). Iron wire, on the other hand, has quite a bit of resistance, and may become hot when many electrons are retarded in their passage. Heavy thick wire—which permits the easy passage of millions of electrons — has less resistance than fine, thin wire of the same material—which slows up the electron flow (See Fig. 4).

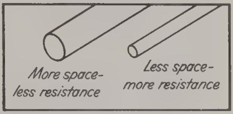


Figure 4. Relation of wire-size to resistance.

Some substances other than metals have extremely high resistance; they permit very few electrons to pass. Some of these substances are rubber, bakelite, glass, and porcelain. Because of their high resistance they are used as insulators. There is no such thing as an absolute non-conductor.

The unit of measurement for resistance is the ohm. Assume that we have a battery of one volt connected to a wire of one ohm resistance. Then an electrical current of one amp will flow. You can see, now, that the voltage, the current, and the resistance of any circuit are inter-related. In Direct Current circuits, this relationship is expressed mathematically according to Ohm's law: $E = I \times R$. In this formula, each symbol stands for one factor; E for voltage, I for current in Amperes, and R for resistance in ohms.

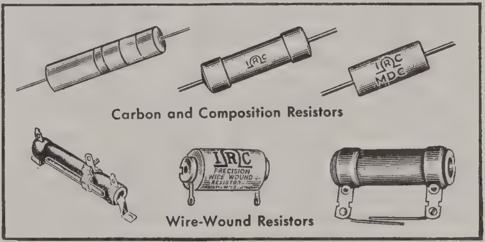

IRC
IRC MDC
Carbon and Composition Resistors
IRC PRECISION WIRE WOUND RESISTOR
Wire-Wound Resistors

Figure 5. Several different types of fixed resistance.

Commercial resistances, or resistors, possess a variety of physical shapes, some of which are shown in Fig. 5. The two most common types possess either carbon or composition construction. They occur largely in the tubular form shown in Fig. 5 and are available in a wide range of values from a few ohms to many millions of ohms. The values may either be printed in figures on the side of the resistor body or a color code may be employed. For the latter, the Electronic Industries Association (EIA) has adopted a standard system assigning numbers to specific colors to indicate the resistance value. Since resistors are used in all radio circuits, it is important that the radio beginner learn how to read this color code.

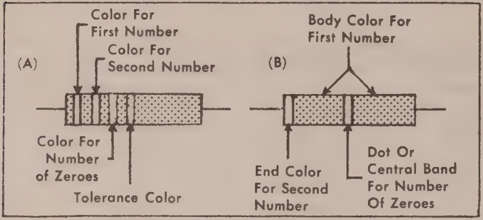

(A)
Color For First Number
Color For Second Number
Color For Number of Zeroes
Tolerance Color
(B)
Body Color For First Number
End Color For Second Number
Dot Or Central Band For Number Of Zeroes

Figure 6. Two ways of color-coding resistors.

Most manufacturers use three colored bands painted at one end of the resistor. See Fig. 6A. Reading from left to right, the first band indicates the first figure, the second band the second figure, and the third band the number of zeros following. For example, if the colors on a resistor are Red, Violet and Orange, its value is 27,000 ohms (2 for Red, 7 for Violet, 000 for Orange). The table below indicates all color and figure combinations.

First Band (1st Figure)	Second Band (2nd Figure)	Third Band (3rd Figure)
0—Black	0—Black	None—Black
1—Brown	1—Brown	0—Brown
2—Red	2—Red	00—Red
3—Orange	3—Orange	000—Orange
4—Yellow	4—Yellow	0000—Yellow
5—Green	5—Green	00000—Green
6—Blue	6—Blue	000000—Blue
7—Violet	7—Violet	
8—Gray	8—Gray	
9—White	9—White	

A fourth band may be used to indicate tolerance, that is, a measurement of the maximum amount by which the resistor may vary from its rated figure. Silver indicates 10%, Gold 5%. 20% is indicated if no special tolerance band is present. A 10% or 20% resistor is commonly used in radio circuits unless close tolerance is specifically demanded.

Some manufacturers use another system, in which "Body", "End" and "Dot" colors are employed. See Fig. 6B. Body color indicates the first figure, an end color the second, while the dot represents the number of zeros following. Color values are the same as those in the other system.

A handy pocket-size guide with rotary discs showing band or body, end and dot colors of resistors according to EIA standard color-code can be purchased from Allied. This pocket guide shows the figure for each color on each scale so that resistance values can be obtained instantly.

Another important characteristic of a resistor which must be specified when resistors are purchased is the wattage rating. This indicates the ability of the resistor to dissipate the heat which is generated when current flows through it. The unit of measurement is the watt. The most common wattage ratings for carbon and composition resistors are ¼, ½, 1 and 2 watts.

The heat generated by a resistor is governed by two factors: the amount of current passing through the unit and the value of its resistance. Of the two, current is more important because if we double the current, we increase the power dissipation by the square of this or 4 times. On the other hand, if we keep the current the same and double the resistance, the power dissipated also rises by a factor of 2.

It is important that the proper wattage rating be specified, because a resistor with too low a rating will soon char and burn out. On the other hand, there is no point in using a resistor with a much higher than needed rating because cost rises rapidly with power rating.

Generally speaking, the longer and wider a resistor, the higher its power rating.

Another type of resistor that is widely used because of its ability to be designed with high wattage ratings is the wire-wound resistor. This can either be fixed in value, or come with a central slider ring that enables the user to obtain various resistance values from zero up to the full value of the unit. In general, these resistors are not available with values as high as carbon or composition resistors, but they are seldom required above 100,000 ohms. They find their greatest application in power supply circuits where high currents prevail.

Wire-wound resistors are seldom color coded; rather their actual value is stamped somewhere on the unit. In the higher wattage ratings, these units may possess a hollow core to assist in dissipating the heat generated.

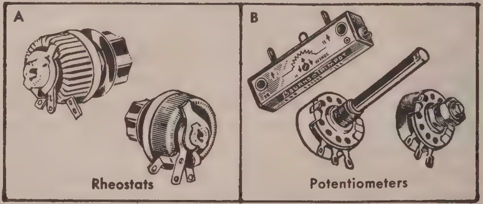


Figure 7. Several types of variable resistors.

Also part of the resistor family are the potentiometers and rheostats shown in Fig. 7. These units are circular in shape, with a central arm that has a shaft attached to it. When the unit is mounted on a chassis, the shaft protrudes far enough out to enable it to be grasped and rotated. The movable arm makes contact with the internal resistance element of the rheostat or potentiometer and, as it rotates, the amount of resistance between the arm and either end terminal varies. Thus, if we place a certain voltage across the unit, we can pick off any portion we desire simply by rotating the arm.

This, incidentally, is the way the volume control (which is a potentiometer) on a radio set operates. Potentiometers and rheostats are used also for tone, contrast and brightness controls, to mention a few of their more common applications.

Potentiometers and rheostats are similar in many respects, their chief difference being the fact that in a rheostat, only one end terminal and the center arm are electrically connected into the circuit. A potentiometer has both end terminals and the arm active in the circuit.

The Battery

In the early days of radio, batteries were used as the source of power. Even today in communities not yet reached by power lines, battery-operated radio receivers of the modern type afford facilities for quality reception.

Batteries are simple chemical machines producing electrical current from a chemical reaction. A battery consists of a number of cells, each cell producing a quantity of electricity. The ordinary flashlight cell, for example, produces 1½ volts. In such a battery the zinc can is used as the negative terminal, and a carbon rod in the center of the cell is used as the positive terminal. Inside the cell are a number of chemicals; a chemreaction takes place each time current is drawn from the battery. The larger "B" batteries are simply composed of a number of these smaller cells connected together.

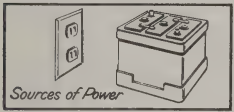
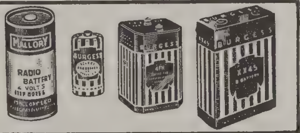


Figure 8. Electric power is obtained from battery or light outlet.

Figure 9. Common dry-cell batteries.



There are two chief types of batteries. One which produces electrical current of itself until it is discharged, and must then be discarded, uses primary cells. This is the familiar dry cell described above. The other, the storage battery used in automobiles and for radio service, is known as the secondary cell type. It acts as a reservoir of electrical energy. First, the electricity must be "poured" in—that is, the battery must be charged. After the battery has been charged, electricity may be drawn out until the battery becomes discharged, at which time it must be charged again, and so on.

Magnetism

Another force closely related to many radio and electrical components is magnetism. Transformers, motors and generators, loudspeakers, relays, and other radio parts, operate on the principle of magnetism. Since magnetism is similar to electricity, we cannot really see it or feel it, but its effect can be detected and accurately measured.

As you already know, a magnet will attract objects made of iron or steel. This is accounted for by the fact that any magnet has two poles of opposite polarity (that is, of opposite force). When two separate magnets are brought together, the like poles will repel each other, while the unlike poles will have a strong attraction for each other. This is the same as the action of electrons and protons. Since the entire earth may be considered as a giant magnet, a compass using a small magnet on a pivot will tend to point to the North and South Poles.

One of the laws of magnetism we might mention is that the force of attraction and repulsion between two magnets is inversely proportional to the square of the distance. North and South magnetic poles will attract each other four times as much at a distance of one inch, as at a distance of two inches. When a magnet is dipped into iron filings, most of the filings stick to the poles, indicating that the force of attraction is greatest at the poles (Fig. 10).

Magnetism may also be produced by the flow of electrical current through a conductor. Every wire which carries electrical current has a magnetic field around it proportional to the current strength and the placement of the wire. By winding a number of turns of wire in the form of a coil, a much stronger magnetic field can be produced, since the field of each individual turn will add up. And, since the magnetic field of force of each turn is added to that of the next turn, the greater the number of turns of wire, the stronger the magnetic field.

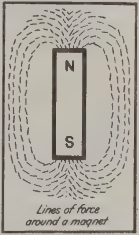


Figure 10.

The total magnetic flux (lines of force) depends on the number of turns and the strength of the current. If the current is strong, relatively few turns of thick wire will be required. On the other hand, if the current is weak, a great many turns of thin wire will be needed for the same magnetic force.

A stronger electromagnet can be made if a bar of iron is placed in the center of a coil, since the lines of force produced will be concentrated and stronger magnetic action will result. In any electromagnet, of course, the magnetism will be lost immediately when the current is shut off, whereas in natural magnets the magnetism is more or less permanent.

Inductance And Reactance

The property of a coil to set up a magnetic field when current is flowing through it is called inductance. Such a coil tends to oppose any changes in current intensity.

The opposing force of an inductance, known as reactance, is directly proportional to the inductance of the coil. The inductance is measured in units called henries, while the reactance is measured in ohms. (In radio work, the henry is rather too large, and so the millihenry—one thousandth of a henry—and the microhenry—one millionth of a henry—are commonly used terms.) The same inductance will have a greater reactance at a higher frequency. This is why an R.F. choke will have a "choking" effect on high radio frequencies, but will permit low frequencies and D.C. (direct current) to pass unobstructed.

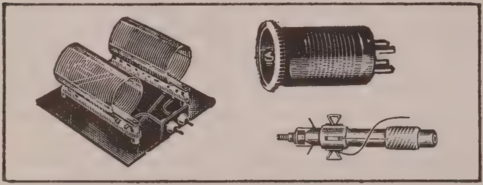


Figure 11. Three types of coils.

Some of the forms and shapes that coils take are shown in Fig. 11. For low-frequency operation, as in the power supply section of a receiver where the operating frequency is either 60 cycles or 120 cycles, iron-core coils known as chokes are used. At much higher frequencies, such as those found in the signal tuning circuits of a receiver, the coils either have nothing but air at their center (hence known as air-core coils), or else they possess small powdered iron cores. In general, the high-frequency coils tend to be smaller in physical size than the low-frequency coils.

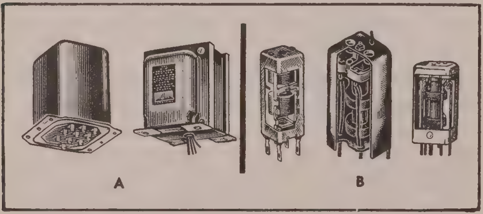


Figure 12. Low and high-frequency transformers.

The name coil is reserved generally for inductances having a single winding. When two or more coils are wound on one form so that their magnetic fields interact, the combination is known as a transformer. As with coils, low-frequency transformers (such as the power transformer in a receiver) possess iron laminations (see Fig. 12A); at higher frequencies the core may either be air or powdered iron. (See Fig. 12B).

So far, in talking of electric current, we have assumed that it is a steady flow of electrons in one direction. However, unlike Direct Current, which is a steady flow in one direction, Alternating Current (A.C.) is constantly varying in intensity and in direction. A.C. current—as the name implies—flows first in one direction and then in the opposite direction. The change in direction does not occur abruptly. In one-half a cycle the voltage and current will rise from zero to a peak value and go down to zero again. Then, without stopping to take a breath, it starts in the opposite direction, rising to a peak value and then decreasing to zero. This completes the cycle (Fig. 13). The same variations go on as long as current is flowing. In 60 cycle current, which is now largely standard for power circuits in the United States, these complete cycles take place sixty times each second. In radio circuits the changes (frequency) may take place many thousands or even millions of times per second.

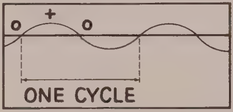


Figure 13. The alternating current cycle.

Capacitance

Two similar metal plates facing each other, but separated by air or a thin piece of insulation (dielectric), form a capacitor. If such a capacitor is connected to a battery, electrons will flow from the plate connected to the positive terminal of the battery, through the battery to the opposite plate. By disconnecting the battery and shorting the capacitor, the electrons will pass back through the shorting wire and on to the other plate again. (Fig. 14).

Capacitance (storage ability) of a capacitor depends on three factors: (1) size of plates, (2) spacing of plates, and (3) the dielectric used. The larger the plate area, of course, the greater the capacity.

The unit of measurement is the farad. However, one farad of capacity is a much higher value than is ever used commercially; therefore, the microfarad (millionth of a farad) or the micro-microfarad (millionth of a microfarad) is used. These are abbreviated thus: mfd, mmf (or mmfd).

Different dielectrics give different total capacities, even though the plates and spacing are not altered in any way. If a capacitor has a given capacity with air as the dielectric, it will have seven times the capacity with mica substituted as the dielectric. The dielectric constant of air is taken as 1, of mica as 7; other substances have their corresponding dielectric constants.

Capacitors not only store up energy, but are also important in radio work for another reason. If a capacitor is connected in a circuit with direct current being supplied, it permits the current to flow only for a very short time while it is being charged. If alternating current (see Fig. 13) is supplied, the capacitor will permit the current to flow through the circuit. Thus, a capacitor which permits A.C. to flow, but does not allow D.C. to pass through, is called a blocking capacitor; one which permits A.C. to pass through a shorter path than D.C. would follow, is called a by-pass capacitor.

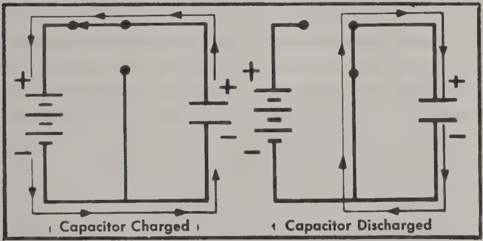
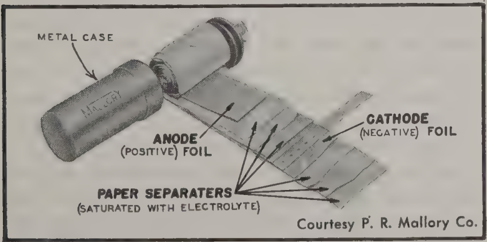


Figure 14. Current flow in a charged and discharged capacitor.

In many radio capacitors waxed paper or mica is used as the dielectric. Those circuits in which D.C. or pulsating D.C. is present may use electrolytic capacitors in which an extremely thin film forms on one of the plates and serves as the dielectric. Since this film is extremely thin, it permits high capacity units to be constructed very compactly. The cutaway illustration (Fig. 15) shows clearly the construction of an electrolytic capacitor. The cathode and anode foils are the plates.



Courtesy P. R. Mallory Co.

Figure 15. Unrolled view of Dry Electrolytic Capacitor.

The chemical nature of electrolytic capacitors adapts them particularly to use in power supply circuits which deliver up to 600 volts D.C.

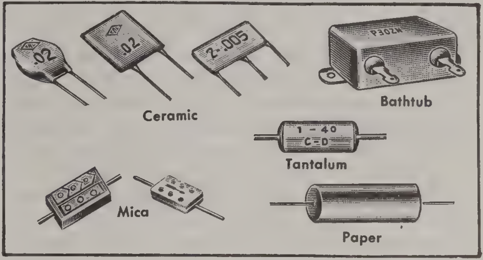


Figure 16. Assorted types of commercial fixed capacitors.

A wide variety of other commonly used capacitors is shown in Fig. 16. The names of most of these are derived from the type of dielectric employed internally, i.e., mica, ceramic, metallized paper, etc. Others are designated according to shape, as "bathtub," tubular, disc, etc.

In specifying capacitors, two qualities are important, capacitive value and voltage rating. The latter figure represents the highest voltage that a capacitor should be subjected to. Thus, a 200-volt unit should not be used in any circuit where the voltage rises over 200 volts, even momentarily. While most capacitors possess a safety factor beyond the voltage stated, it is not recommended that this be taken advantage of.

Many small capacitors are color coded with the same code employed for resistors. For capacitors, all readings are in micro-microfarads (mmfd). A 250 mmfd (.00025 mfd.) would be coded as follows: red dot (2), green dot (5), brown dot (1 zero). Additional information on color coding for capacitors will be found in ALLIED's ELECTRONICS DATA HANDBOOK.

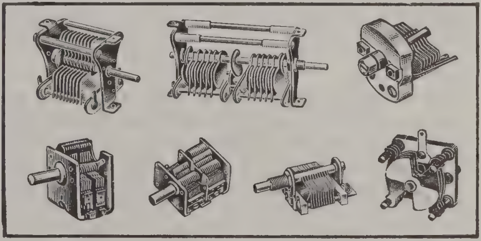


Figure 17. Variable capacitors of various types.

Variable capacitors generally take the form shown in Fig. 17. They are used principally to tune the front-end circuits of a receiver so that different stations can be received. There are other forms of tuning, but this is common in radio and F-M receivers.

The Parts Of A Radio Set And Their Functions

In the simplest language, a radio receiver is nothing more than a device to capture radio signals which travel through space and to reproduce them as audible sound.

These radio signals, of course, are emitted by the transmitter where the process is just the reverse of that in a radio receiver. In other words, a transmitter converts audible sound into radio signals and radiates these signals through space.

Now, how are these signals which we cannot see or hear or feel captured by the radio set and transformed from mere electrical impulses into the voice of a popular singer or the music of a renowned symphony orchestra?

This is a good place in which to explain the functions of the various radio parts so that when you come to a later section in which we tell you how to construct a set, you will understand why a great variety of parts is needed and what these parts do.

Broadly speaking, any radio receiving set uses all, or some, of the sections (stages) listed below, All are involved in changing those invisible, intangible radio signals into sound that you can hear. These sections are:

1—The Antenna
2—The Radio Frequency Amplifier
3—The Converter
4—The Intermediate Frequency Amplifier
5—The Detector
6—The Audio Frequency Amplifier
7—The Loudspeaker or Headphones.

And what, you will ask, do these do?

Consider first the Superheterodyne circuit. The antenna, which is a piece of wire, picks up radio signals which are travelling through space all around us at an approximate speed of 186,000 miles per second. This great speed explains why radio broadcasts can be picked up almost simultaneously by receivers located at opposite corners of the earth.

The strength of this signal on the antenna is only a few millionths of a volt—so it goes to the Radio Frequency amplifier to be strengthened. The RF amplifier is a tube in a circuit which can be tuned (by your radio dial) to provide maximum amplification on the frequency (station) you want to hear.

This amplified signal (from 30 to 100 times greater than the signal at the antenna) goes now to the converter where it is changed to a lower frequency which can be amplified more efficiently.

The new, lower frequency is called the Intermediate Frequency or IF. The IF passes through one or more stages, each consisting of a tube and a circuit, fixed tuned to the IF (usually 455 kc).

Now amplified from 100 to 150 times, the IF goes to the detector, where roughly speaking, the carrier frequency (RF) is removed and only the Audio Frequency (AF) component remains. The detector is usually a diode-type tube.

Next the AF amplifier increases the strength of the AF signal so it can move the speaker voice coil or headphone diaphragm and—at last—cause audible sound.

In a Tuned Radio Frequency (TRF) receiver the procedure differs only in that there is no converter and no IF stages.

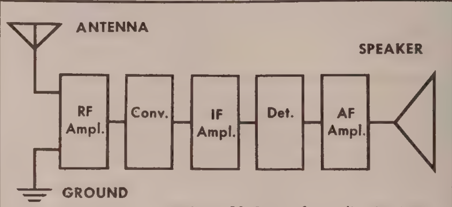


Figure 18. Parts of a radio circuit.

Actually, this whole process we have described takes place in a period of time so short that it can scarcely be measured. Practically speaking, the sound of the program you hear leaves the loudspeaker at almost the same instant it has entered the antenna as radio signals.

In order to operate the tubes used in a radio set, it is necessary to employ some form of electrical current, whether it be from batteries or from a regular electric outlet in the wall. If you live in a city, you probably have 110 volts 60 cycles Alternating Current. Since the tubes used in a radio set require direct-current power to make them operate, it is necessary to transform and convert the incoming voltage to the proper type and amount needed for the tubes.

This is the function of the transformer, the rectifier, and of the filter network in the set. These components make up what is called the power supply.

Capacitors and coils, when used together, comprise what we call the tuned circuits. When adjusted by the knob controlling the capacitor to the frequency or wave length of the station wanted, the tuned circuit passes signals from that desired station to the tubes, from which point the process goes on as we have already described it.

As for the remaining parts used in a radio set, we may say that a potentiometer is a type of variable resistor which is generally used as a volume control. A choke is a fixed inductance (see page 14) employed to prevent the passing of either audio frequency or radio frequency voltages, depending upon the type of choke used. Sockets are necessary to hold tube or coils in place and to permit correct wiring connections to be made to the various parts of the tubes or coils. A chassis base is needed to provide a foundation for the parts in the set. The dial is required so that we can revolve the tuning capacitor and locate stations at a definite point on the dial scale. Wire and hardware, including screws, cords, clips, plugs, etc., are needed to make the connections between the various parts of the circuit and to hold all parts rigidly in place.

By now we have said practically everything that the beginner needs to know about the various radio parts. Something more must be told about tubes—their various types and their functions—but we shall reserve that for a later section.

The Tools Needed For Radio Construction

In order to assemble the various parts of a radio set, you will require a number of simple, inexpensive tools. No doubt you already have some of these tools somewhere about your home.

Practically all the radio work encountered by a beginner can be taken care of with these tools:

1 soldering iron (60-100 watts) or soldering gun (100-250 watts).
1 pair of long-nose pliers
1 pair of diagonal cutters
1 screwdriver (5″ or 6″ size)
1 screwdriver (2″ or 3″ size)
1 drill kit, consisting of hand drill and assorted drills such as Nos. 11, 18 and 27
1 center punch
1 hammer
1 steel rule (12″ size)

Optional Tools

1 vise (4″ size)
1 hacksaw
1 square
1 file (medium coarse)

As a matter of fact, you can assemble many radio sets (for example, the Knight-Kits shown in the section beginning on page 33) with only three tools: screwdriver, soldering iron, and pliers. This is because special care has been taken to supply such kits in a form which will require a minimum of work and ingenuity on the part of the radio builder.

However, since punched and drilled chassis are not always available as, for instance, in the construction of most circuits described in the various radio magazines, the three essential tools will not be enough. You will need to make use of most or all of the tools listed above.

Care Of Soldering Irons And Guns

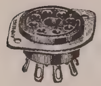
In the construction of a radio set, or practically any other electronic equipment, wire connections to sockets, coils, terminals, and to printed circuits are made by means of soldering. Since this equipment cannot perform properly, or may not operate at all if solder connections are poor, it is important that your iron or gun be kept in good working condition. The soldering iron or gun is the most frequently used and most important tool in electronic assembly — with proper care it will do a fast, efficient job and should give you years of dependable service.

When you buy a soldering iron, it will have a clean, shiny copper tip. Before using the iron, be sure to melt solder over the entire exposed surface of the tip, until it is covered completely with a coating of solder. This process is called "tinning." Tinning not only protects the tip from oxidation, but also makes for easier, more efficient soldering.

The tip of a soldering iron should always be cleaned and well tinned. If it gets black and crusty, this means that it is being oxidized and that cleaning is necessary. To clean the iron, wipe the tip with a heavy piece of cloth or felt which you may fasten to your workbench. However, if the tip has been allowed to become badly oxidized, the crusty material, as well as any pit marks which appear, should be removed with either a file or sandpaper. After restoring the tip to a smooth finish be sure to recoat any bare copper surfaces with solder.

Soldering guns require very little care. Since the tip is hot only for very brief periods during actual soldering, tip oxidation seldom presents a problem. However, if the tip does become oxidized, a file or piece of sandpaper may be used to remove the crust, or any pits, which may have developed.

Common Radio Parts And Tools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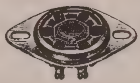
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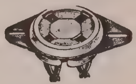
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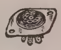
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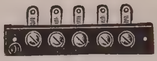
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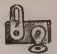
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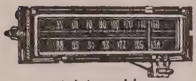
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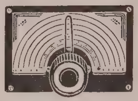
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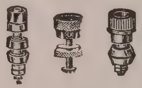
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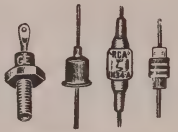

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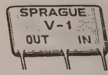

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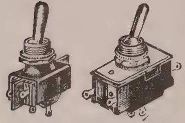
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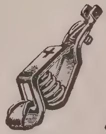
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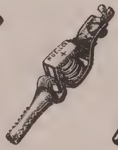
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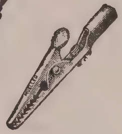
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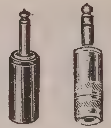
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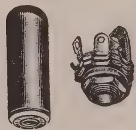
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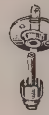
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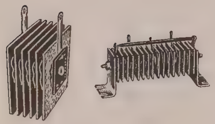
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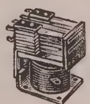
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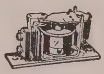
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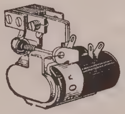
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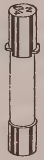
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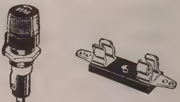
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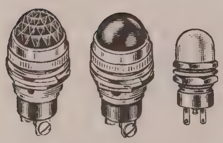
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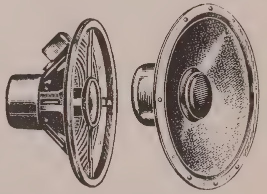
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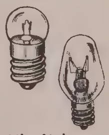
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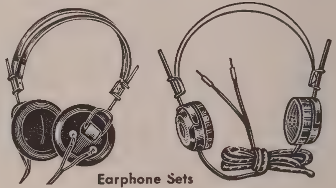
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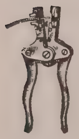
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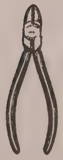
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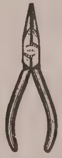
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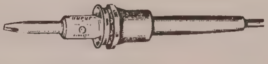
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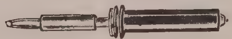
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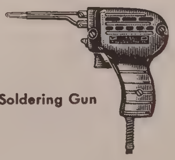
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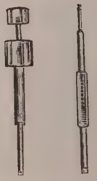

Alignment Tools

Getting The Right Chassis Base

If you look into the cabinet of your home radio set you will notice that all of the tubes and other parts are mounted on a metal base. This is known as a chassis base. All commercially built radio receivers use a base of this type. Chassis bases, made of either steel or aluminum, are commonly used in radio work. Aluminum chassis are excellent for most applications and are particularly recommended for beginners, since aluminum is soft and can easily be cut and drilled with hand tools. Though not as rigid as steel chassis, aluminum chassis provide plenty of strength for most uses. Aluminum is, of course, substantially lighter in weight, and this is advantageous when equipment must be as light as possible. Steel chassis bases are excellent where high rigidity is required, such as for circuits where heavy components are used.

Many experimenters prefer using a wood base. A piece of wood, about half an inch thick, sandpapered to a smooth finish and stained, is all that is needed. Parts are mounted on the surface of the board with wood screws and no drilling or punching of the base is necessary. The use of a wood base is a simple, low-cost means of working on experimental circuits, since if any changes in wiring must be made, parts can easily be moved without the necessity of drilling or cutting new holes. Then, after all "bugs" are removed from the circuit, it can be reassembled on a regular metal chassis.

Preparing The Chassis Base

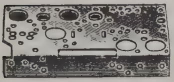


Figure 19. Typical punched and drilled chassis base.

If you use the proper tools you will find that the chassis bases can be rapidly prepared for mounting the necessary radio parts. These tools are low priced and are designed especially to permit ease in use.

The first step is to determine what size chassis base will be needed. If the construction article or parts list from which you are working does not tell you this, it is advisable to lay out the parts to be used in the set on a table and experiment with placement until you have a neat layout permitting short leads. Then estimate what size the surface of the base must be.

Whenever holes are to be drilled in metal, always use a center punch first to locate the exact center of the hole. A valuable guide in this job is a heavy sheet of paper on which an outline of the components, in their exact locations, has been plainly traced. This sketch may easily be fastened to the metal chassis by using gummed paper or adhesive tape. The holes may then be punched through the paper and you will thus avoid marring or scratching the metal surface.

Some care should be taken to get the measurements of the holes as accurate as possible. If the holes are too large, the parts will not fit properly.

To cut out the holes you can use either a drill or a hole-punch. Holes smaller than $\frac{3}{16}$ of an inch can easily be made with a drill. Larger holes should first be made with a small drill, after which larger drills are used to enlarge the hole until the proper size is reached. A circle-cutter or a radio chassis punch is also useful for this work. When cutting holes for tube sockets, a socket punch is the fastest, most convenient tool. Socket punches are available in various diameters to permit cutting holes for the different types of tube sockets used.

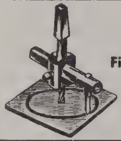


Figure 20. A circle cutter is handy for cutting round holes from ⅝ inches up to 8 inches.

When all holes have been drilled, file or ream off the burrs. You can also give your panels and chassis a professional appearance by painting them with one of the air-drying crackle varnishes or lacquers which are now available in many popular colors.

Mounting The Parts

One aspect of radio building which sometimes puzzles beginners unduly is that of actually mounting the parts on the chassis base. To clear up any vagueness you may have on this subject, we shall talk about this problem now.

In the first place, the chief idea to keep in mind when mounting parts on a chassis is this: Always arrange the layout so that all leads will be as short and direct as possible. Above all, the grid and plate leads must be very short. The reason for this is to assure best operating results, because long leads will result in excessive coupling and stray pick-up, which may prevent the set from performing as it should.

Another point to remember is this: When placing parts tentatively for mounting, see that all controls are at the front panel. For example, the tuning capacitor and its associated dial should be mounted so that stations can be tuned from the front panel. In the same way the volume control, tone control (if any) and other controls such as a rheostat or potentiometer should always be placed so that the control shaft will protrude from the front panel. You can easily see why this is necessary—otherwise, you would have a good deal of inconvenience in operating the receiver.

If the set you are building is described in a magazine construction article, you will usually find an illustration showing how the parts are laid out. It is best to follow such a layout because the author of the article has undoubtedly spent some time in experimentation to assure best results. If you are working from a diagram of the pictorial type, you will also be given definite data as to how parts should be laid out. But remember—always try for the shortest possible leads.

In your first tentative layout of parts, you may find that better wiring facilities can be obtained by changing the position of two or three parts. Accordingly, juggle the parts around until you are sure you have the best possible plan. Then, but not before, go ahead with the final drilling and punching.

Place all mounted parts such as sockets, upright capacitors, transformers, etc., on the chassis in accordance with the holes you have previously drilled. Set in any screws or terminals which hold these parts in place. After all these parts are mounted, you can proceed with wiring.

Making Solder Connections

The performance and dependability of radio equipment depends, to a very great extent, upon the quality of solder connections. Faulty solder connections may result in complete circuit failure, intermittent operation, or poor performance. Therefore, it is of the great importance that you follow good soldering techniques when wiring your set.

As already mentioned, the purpose of soldering is to provide secure, dependable wire connections to sockets, coils, or to other wires. However, do not depend upon soldering alone to provide the correct connections. It is always necessary to hook the wire around the terminals first. Then, after a secure mechanical joint is provided, solder should be applied to seal the joint. Always hold the heated iron or gun to the joint (point of connection) until it becomes hot enough so that the solder, when applied, will melt when it comes in contact with the joint. When the solder runs freely over the joint, the iron or gun must be removed at once, without moving the wire. The connection will then be secure. Be sure to use only enough solder to cover the joint. If too much solder is used, and if it spreads over nearby insulation, it can result in either breakdown of the insulation or excessive electrical leakage between adjacent terminals.

Rosin-core solder should be used for radio connections. When this type of solder is heated, the rosin flux in its core spreads over the joint and removes any oxidation which might otherwise prevent the solder from adhering properly. Never use acid-core solder, since it will corrode the wire to cause a faulty, high-resistance connection.

Checking Your Work

As you proceed with the circuit wiring, use a colored pencil to check off on the diagram each step that you have finished. Unless you do this, you may find that you have omitted some essential bit of wiring and your set will not work. Every part and wire indicated on a circuit diagram is essential if the set is to operate correctly. Make it a habit to check your work as you go along. This will save time in the long run and will assure you of best performance from your radio set.

When you have at last finished mounting all parts, connected all leads, and checked your work, you are ready for the final test. Plug into the electrical outlet (or connect batteries if a battery set), turn on the switch, allow the tubes a few moments to heat up, and then operate the tuning control until you hear a station. If your work has been satisfactory, you will experience quite a thrill in listening to your first program coming in on a set you have built yourself.

Printed Circuits

Until a few years ago, the universal method of wiring a circuit was to use regular hook-up wire between the various components. In the interests of speed in production and in reliability, this method does have certain short-comings. During the war, however, a method was developed by the National

Bureau of Standards whereby the wiring for a specific circuit could be printed directly on the supporting board. Thereafter, the various components could be added easily, often by automatic machinery and then the entire assembly soldered in one dipping operation.

The use of this technique has a number of desirable features. It lowers the cost of manufacture because printed circuit boards can be prepared by automatic means. Furthermore, since all printed boards in a production run are identical, any wiring errors can be totally eliminated. With hand wiring, even using the most skilled workers, this is seldom possible.

Printed circuits are basically an electrical conducting pattern which has been laid down on an insulating support. The conductor is usually copper and the insulator is usually laminated plastic. The sheet of insulation is covered first with a thin layer or foil of copper bonded to one side. To form the necessary wiring, some of the copper foil is removed by a photographic or etching process. That is, the pattern of the wiring is first laid out on the copper foil by applying a chemical "resist" either a silk-screening process or photographically. Then the copper is bathed in an acid bath which removes all of the foil except those portions containing the "resist". The board is then washed to remove the acid, the "resist" is removed, and the result is the printed wiring. Holes are then punched in the board through which component leads are inserted. The component leads are soldered directly to the wiring pattern. The finished product is a circuit with uniform wiring, compact size and entirely without wiring errors.

The excellent operational qualities of printed circuits have led to their widespread use in Knight kits. Not only do they assure uniform quality, but they also shorten construction time considerably. However, since you are dealing with a finely-engineered product, precautions should be taken. Do not overheat the component terminals or the foil. Excessive heat, by applying the soldering iron longer than necessary, may cause the bond between the board and the foil to break. Too much solder may cause a short-circuit to develop between the point being soldered and an adjacent conductor, particularly since many of the printed wires are quite close together.

The Antenna And Ground

To obtain the best results from any radio set—whether a crystal set with earphones or big, deluxe superhet with loudspeaker—you must have a satisfactory antenna and ground connection.

It is impossible to state positively just what type of antenna is best. To determine which is best for any specific installation, you must consider such variable factors as the sensitivity, selectivity, and power of the radio receiver itself; the distance from the nearest broadcasting stations; the number of stations within the local area; the kinds and intensity of interfering devices such as electric flashing signs, trolley-cars, high power lines; the physical conditions which limit space for antenna installation, and so on. We can say, however, that in general for the smaller home-built sets in which good broadcast band reception is the goal, a suitable antenna is a single wire about 50 feet long, installed as high off the ground as possible. That figure—50 feet—should not be taken too literally. We suggest it only because it is about the correct length for a good many installations. If it is found that too many stations interfere and prevent good reception when a 50-foot antenna is used, it is advisable to shorten the antenna. On the other hand, after some experimentation, it may be found that a longer antenna offers better reception. So we say, the length of the antenna required for best reception can be determined only by "trial-and-error" methods.

The ordinary antenna for the beginners' sets may be a length of No. 14 or No. 12 (B. and S. gauge) enameled copper wire. The lead-in (the wire connecting the antenna to the radio receiver) should be a rubber-covered wire. The rubber covering prevents any possibility of grounding if the lead-in comes in contact with a foreign surface. All contacts should be solid and secure. Loose contacts at lead-in or joint may cause noisy, intermittent reception. Solder the lead-in securely to one end of the antenna, and drop it down directly to the receiver where connection is to be made.

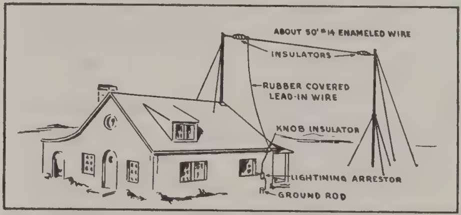


Figure 21. Typical Antenna Installation.

Antennas running in different directions do not have the same pickup patterns, especially on the higher short wave bands. Therefore, if you have plenty of space available, you may wish to install two or more antennas running in different directions to be sure of best possible reception. You will find that each antenna will favor signals coming from different directions. This will permit you to select the antenna which gives strongest reception for the specific station to which you are listening.

There are a number of points concerning which some specific cautions may be advisable:

1—Since the antenna is exposed to the elements, your installation should be strong and secure so that the first high wind which comes along does not blow the wires down. Poles affixed to buildings should be carefully set up and secured.

2—Not too much sway of antenna and lead-in wires should be permitted. If the antenna is installed during warm weather, however allow enough slack so that cold weather will not contract the wires so much that they will snap.

3—Try to prevent aerial or lead-in from touching anything: tree, building, etc. Such contacts cause signal leakage which will result in reduced volume.

4—If there is a high-power line or similar source of interference near your house, run the antenna at a right angle to the source of interference to minimize undesirable effects. Never install an antenna parallel to a high-power line if you want quiet reception from your radio.

Something too, should be said about insulators which are needed for a good antenna installation. There are several types of insulators, the best of which are of glass or glazed porcelain. One insulator should be used at each end of the antenna, and another (of the porcelain nail-knob type) should be used at the window where lead-in enters your house.

We have said the antenna should be installed as high off the ground as possible; a minimum of twenty or thirty feet is usually satisfactory. In the city this is easily done by installing the aerial on the roof of your building. In rural areas, one end may be strung from the roof of your house, and the other from a barn or outlying structure, or a pole.

Indoor aerials, in general, should not be used unless physical conditions are such that the alternative is either an indoor aerial or else none at all. Indoor aerials can never be as efficient as outdoor aerials and at their best are only a compromise. "Aerial eliminators" are not particularly useful if long distance reception is one of your aims, although they are frequently suitable for local-area reception.

A good ground connection is sometimes helpful in improving long-distance reception. Its purpose is to form the second plate of a capacitor, the antenna acting as the first plate. The capacitor is part of the open oscillatory circuit in which the signals flow. The ground wire makes the connection between the "Ground" post of your set and a metal pipe or rod, which is driven into or connected to the earth. Use a ground clamp which will assure a good solid connection. Suitable grounds are: a radiator pipe, a water pipe, or a rod of iron driven into the earth. The ground clamp should touch bare metal; paint or gilt should be scraped off of the pipe used for a ground at the point where the clamp is attached.

In addition to improving reception, a good ground connection should be used for another extremely important reason. Every outdoor aerial should be equipped with a lightning arrestor—and the proper operation of this arrestor is dependent upon the ground connection. Make it a must to install a lightning arrestor as part of your aerial. When properly installed, it will drain off static electricity in the region of your aerial and, thereby, prevent lightning from striking.

To conclude, we might mention the fact that people may tell you of the "marvelous" reception they got without using an aerial at all. That may be —but for consistently good reception, you cannot dispense with an aerial.

NOTE: Receivers of the AC-DC type—that is, sets which are designed to operate from either Alternating or Direct Current rated at 110 or 220 volts—do not have a power transformer in the circuit. Voltages from the power line are obtained directly. Accordingly, no ground connection should be used with an AC-DC receiver unless called for in the circuit.

Radio Tubes: Some Basic Information

Vacuum tubes are the heart of modern radio sets. Ordinarily a receiving tube consists simply of two or more electrodes within an evacuated glass or metal shell (Fig. 22). This glass or metal envelope is needed to maintain the vacuum inside the tube. The vacuum itself is necessary so that the electronic action in the tube can be regulated according to certain specified requirements and so that filaments will not burn out. Only in a vacuum can the flow of electrons to the electrodes be regulated.

As we have already explained (page 9), electrons, essentially, are tiny invisible charges of negative electricity which are capable of traveling at a speed of thousands of miles per second. These electrons make modern tubes possible. Without the constant, regulated flow of these tiny bits of electricity, a tube could not be operated.

Tubes contain several components. The cathode is the element in the tube which supplies the electrons. A directly heated cathode consists of nickel alloy wire coated with a special substance which gives off electrons when heated, The necessary heat is furnished by passing an electric current through the filament wire. (This is one reason for the fact that some kind of electric current—whether from batteries or from an electric outlet—is required to operate any radio set which employs radio tubes.) Examples of directly heated cathode tubes are these types. 1L4, 1R5, 1U5, 3V4 and 1LC6.

An indirect or "heater" cathode tube has a heater or filament inside a metal sleeve. This sleeve is coated with a special substance which emits the electrons. Most present-day A.C. tubes have heater cathodes.

A diode is a two-element tube with a cathode to supply the electrons and a plate to attract and receive the flow of electrons. This plate has a positive voltage applied to it. (Remember that, as we said before, electrons are negative charges; you can see, then, why the plate, which is charged positively, will attract these electrons.) Types 80, 5U4G, and 35Z5 are examples of rectifier diode tubes. Diodes are used most frequently as rectifiers or as special detectors.

A triode is a three element tube. The third element, called a "control grid", is located between the cathode and plate, close to the cathode. Its function is to control the flow of electrons to the plate. As electrons are negative electrical charges, they are repelled and prevented from passing to the plate when a negative potential is applied to the grid When the potential to the grid is made less negative (or more positive) it permits electrons to reach the plate. A change of just a few volts to the grid is enough to permit or prevent passage of electrons. Thus, a small change in grid voltage is sufficient to control the large current passing through a tube and results in a high degree of amplification. Almost any desired level of amplification can be achieved by adding additional tubes. Commonly used types are the 6C4, 6C5, 6J5 and 7B4.

In actual operation the grid voltage is kept slightly negative to limit the flow of electrons. When you tune in a program from a radio station you are actually picking up a small electrical charge and adding it to the grid voltage now on your tube, thus making it sufficiently positive or negative to increase or decrease passage of electrons. This picked-up signal is not constant. It varies in accordance with the speech or music being fed into the broadcaster's microphone, and so permits a varying flow of electrons (duplicating the program) to flow from cathode, through the grid, to the plate. The varying electron flow is an electrical picture of the program, and is changed to sound by your speaker.

The 3 elements in the triode—grid, plate, and

Structure Of Miniature Pentode-Type Tube

1. Glass Envelope
2. Internal Shield
3. Plate
4. Grid No. 3 (Suppressor)
5. Grid No. 2 (Screen)
6. Grid No. 1 (Control)
7. Cathode
8. Heater
9. Exhaust Tip
10. Getter
11. Space Shield Header
12. Insulating Spacer
13. Spacer Shield
14. Inter-Pin Shield
15. Glass Button-Stem Shield
16. Lead Wire
17. Base Pin
18. Glass-to-Metal Shield

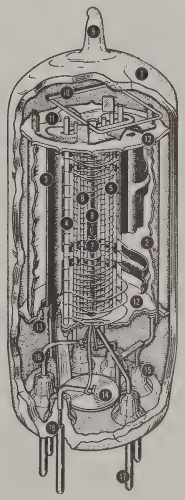


Figure 22. Cross-section of a typical RCA Miniature Tube. This diagram illustrates in detail the construction of a modern radio tube. All elements are clearly indicated. The complexity of the modern tube is here readily apparent. A good basic understanding of tube design and function is essential to good radio building.

cathode—have existing capacities among themselves which are detrimental to perfect operation. The capacity between grid and plate limits the possible gain (or increase in amplification).

Accordingly, while a triode represents an advance over the diode tube, a still greater advantage was made possible with the invention of the tetrode. (The names given to these tubes can easily be explained when you remember that diode means two elements; triode means three elements; tetrode means four elements and pentode means five elements.)

A tetrode is similar to a triode but has an additional screen grid to eliminate the undesirable inter-electrode capacity which is found in triode tubes. This screen is mounted between the grid and the plate, connected to a positive potential, and by-passed to ground. Representative types of tetrodes are the 1A4GT and 7G8.

A phenomenon known as "secondary emission" —the only limitation of the tetrode tube—is eliminated by adding a suppressor grid between the plate and screen grid. This suppressor is connected to the center tap of the filament or cathode (as in the 6SG7 and 6F6) or is brought out externally in some types such as 6AU6, 6BA6 and 12SJ7GT.

For the purpose of the beginner this information on tubes is sufficient. However, as you advance in your radio work you will want to know more about tube theory and function; you can acquire this advanced knowledge from any one of a dozen tube manuals or radio theory books (see page 30).

The various tube manufacturers make available without charge, characteristic tube charts which set forth the average characteristics of all types of tubes under a given set of applied voltages. These charts show the recommended grid and plate voltages and in practice may be deviated from within narrow limits without affecting the operation of a tube. Filament voltages as shown by the charts are maximum values, however, and cannot be exceeded without seriously shortening the life of the tube or even causing a failure of the filament through burn-out.

Coils

We have previously mentioned the fact that coils are used in the tuned circuit or circuits of a radio receiver, but we have said nothing about these coils. Essentially, they are used to permit reception of radio signals on specific frequencies as desired. For example, a set of Short-Wave coils is required to cover Short-Wave frequencies, and Broadcast coils are needed to cover the Broadcast band.

As we have already stated, a magnetic field is set up around a coil of wire through which current is flowing. This field follows in intensity the strength of the exciting current. The number of turns of wire on a coil determines the portion of the radio spectrum which can be covered with a given tuning capacitor.

Coils are wound with magnet wire on forms usually made of bakelite or similar composition material. For convenience in changing bands, some coil forms have prongs at the base such as radio tubes have. Thus, to change bands, you remove one coil from its socket and replace it with another coil that covers the desired band.

In many receivers all the coils for the various bands are permanently installed and are wired to a selector switch. By merely turning the switch, the proper coils for any desired band can be selected. This arrangement makes it unnecessary to use the plug-in arrangement.

Coils must be made specifically for particular receivers because the physical size of the coil, wire size and number of turns on the coil may be different for each receiver. In most cases coils for specific receivers will be purchased completely constructed. For this reason, no winding details for coils are given here. If for some reason the experimenter finds it necessary to wind some coils for a particular receiver that he is building, winding details will be given together with other constructional details for that receiver.

Transistors

The transistor, first introduced at Bell Telephone Labs in June, 1948, is considered one of the electronic marvels of the age. Its invention promises to have as far reaching effects as the invention of the triode vacuum tube. Transistors have already widely replaced vacuum tubes in hearing aids, radios, and such advanced equipment as computers and electronic "brains". Transistors not only can do most of the things that vacuum tubes do, but they can be used in applications where use of the vacuum tube would be impractical.

The general acceptance of transistors is credited to their extreme versatility and the many advantages they offer. Transistors can be operated from extremely low voltages, thus cutting the cost of power supplies. They are very small (see illustration), permitting the design of much more compact equipment. Their light weight, only a fraction of a tube's weight, makes them ideal for portable equipment. They are highly efficient as practically no heat is generated in operation. Their rugged construction makes them especially suitable for use in aircraft, missiles, industrial applications, or anywhere severe vibration may be encountered. In addition to these advantages, modern production methods are reducing the cost of transistors to a point where their extremely long life makes them potentially less expensive than vacuum tubes.

Since, from all indications it appears that transistors will play an ever more important role in electronics it is important that the beginner in radio have some understanding of what transistors are and how they are made. To begin with, transistors are made of crystalline materials called "semi-conductors." These materials are so called because they act like conductors under some conditions and like insulators under others. The galena crystals used in crystal radio sets are one example of "semi-conductors". Other examples include selenium rectifiers, photocells, and silicon and germanium diodes. As previously stated, a diode is a two element device. In a broad sense, the transistor is simply a "semi-conductor" that incorporates three elements; namely, the emitter, base, and collector. These elements correspond to a certain extent with the cathode, grid, and plate of a triode vacuum tube. Germanium is the material most widely used in the manufacture of transistors. It was found that by adding a trace of a specific foreign material to pure germanium, either positive (P), or negative (N) material can be formed. Transistors are made of three layers or sections of these P and N materials combined in either N-P-N or P-N-P sequence. Leads are connected to each layer or section in the transistor to permit making external connections.

The two most popular types of transistors currently available are the "junction" and the "point-contact" transistors. These names indicate the manner in which the P and N sections of the transistor were formed and also, to a certain extent, the application for which the transistor was designed. Most junction type transistors are designed to operate as oscillators, AC or DC amplifiers, buffers, mixers, etc., at frequencies up to about 30 mc. Point-contact transistors are particularly suitable for switching circuits as in computers, and for high frequency applications.

New types of transistors for higher power and higher frequency applications are appearing all the time and these promise an ever expanding field of application in electronics.

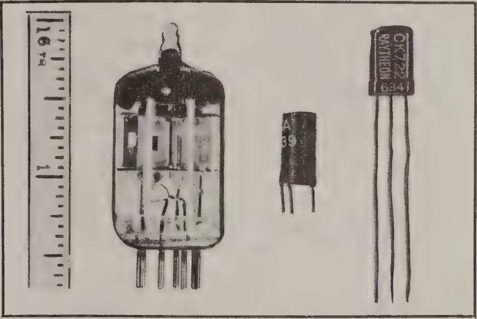


Figure 23. Size comparison between a 6AL5 miniature tube and transistors.

Originally, two types of transistors were developed, junction and point-contact transistors. These names indicate the manner in which the P and N sections were formed in the manufacturing process. At first, point-contact transistors were employed for high-frequency circuits (above 5 mc) whereas junction transistors were best applied in low-frequency circuits (below 5 mc). However, with improvements in fabrication techniques, junction transistors are now able to operate well into the hundreds of megacycles. For this reason they have largely replaced point-contact transistors in all but a few applications such as the switching circuits of computers.

Additional transistor types are also available, such as the tetrode, PNPN, field-effect and thyristor transistors. Undoubtedly others will appear as the state of the art progresses. This applies particularly to high power transistors which are now in considerable demand in all types of electronic equipment.

In dealing with transistors physically and electrically, there are a number of precautions that must be observed in order to prevent their destruction. Physically, there are two ways to mount a transistor in a circuit: by plugging the leads into a special socket, if they are stiff enough, or by soldering the leads directly to the circuit components. For the latter operation, a low-wattage (35-

40 watts) soldering iron is required. This is because transistors are exceedingly sensitive to heat and the heat generated by a normal soldering iron (100 to 200 watts) could cause the transistor terminal leads to become hot enough to damage the transistor internally.

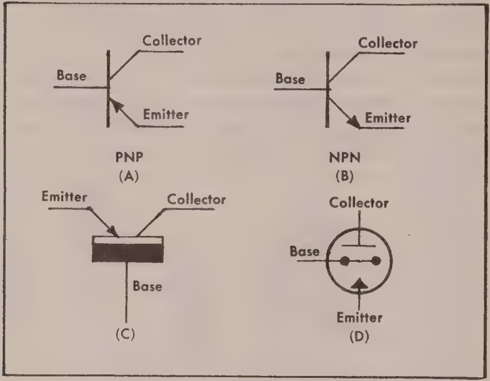


Figure 24. Schematic symbols for transistors.
(A). Symbol for a PNP transistor. (B). Symbol for an NPN transistor.
(C)-(D). Two alternate transistor symbols.

To provide the transistor with the maximum protection while it is being soldered or unsoldered, it is good practice to grasp the terminal lead tightly with long-nose pliers positioned between the transistor body and the lead end. With this arrangement, any heat travelling along the wire will be shunted away from the transistor housing. It is desirable to retain the pliers on the wire for a short time after the iron has been removed to make certain that all of the heat has been dissipated. It is also good practice to provide such a heat shield when other wires are being soldered to any terminal lugs to which a transistor lead is attached. Two helpful rules to follow are to keep the transistor leads as long as possible, consistent with the space available and the application, and to get whatever soldering has to be done over with as quickly as possible. Helpful in this respect is 60/40 low-temperature rosin-core solder.

When transistors are plugged into sockets, make certain the unit is out of the socket when the soldering iron is brought into contact with any of the socket terminal lugs.

As a final word concerning the use of any tools on transistors and their associated miniaturized components, always remember that because these units are small, their connecting wires are quite fragile. Handle these wires carefully and gently, both when the part is being installed and when it is being removed.

Electrically, there are also some precautions that must be observed when dealing with transistors. Scrutinize carefully the value and polarity of any voltages (from batteries or other power sources) that are being applied to a transistor circuit. Make certain first that you have the voltage called for, then check polarity before final connection is made to the circuit. If you are at all in doubt about the latter point, check the type of transistor being employed. PNP units require negative collector voltages and positive emitter voltages, both taken with respect to the base. In NPN transistors, the reverse situation holds.

Before the battery is connected in the circuit, the various transistors should be firmly in place. Never insert or remove a transistor when voltages are present. This is designed to prevent the appearance of surge currents which, if they are powerful enough, can permanently damage a transistor. Always remove the voltage first. If you are experimenting with a new circuit or building a kit, double check all wiring before applying bias voltages.

One final word about the precautions to observe when positioning transistors in electronic equipment. Keep transistors clear of any component, be it tube, resistor, or transformer which passes enough current to develop a noticeable amount of heat. The ratings specified for transistors are always given at a certain surrounding temperature, generally 25°C. For every degree above this figure, a corresponding lowering of the transistor ratings must be made, thereby effectively reducing the operating range of the unit. It might be useful to remember this when you find that transistor equipment is not operating as it should and there is no component that is apparently at fault. Check the temperature near the transistor (with a thermometer) with the equipment in operation. If it is higher than it should be, then try to get it back to normal and see if proper operation is obtained.

High Fidelity

High fidelity is a term that is applied to audio equipment capable of reproducing music in your own home with the range, vitality and naturalness you hear and enjoy when you are actually present at the original performance. There are many factors that make this concept of musical enjoyment possible, but three characteristics stand out above all others. These are Minimum Distortion, Wide Frequency Range, and a Balance of Tone.

Minimum Distortion: If you have ever looked at a photograph or motion picture that was not in focus, you know the meaning of distortion. The image is fuzzy, blurred, and undefined—completely disturbing to the eye. Sound can be similarly distorted and equally offensive to your ears. Distorted sound is fuzzy, and you hear it as a blur of noise rather than as a clear distinct musical note. You get this kind of distortion in most commercial instruments of low or average quality. In high fidelity, however, all of the components are specially designed to keep distortion at an absolute minimum.

Wide Frequency Range: High fidelity components have the ability to reproduce the entire range of musical sound with equal realism, from the lowest note of the organ to the highest note of the triangle. It is this ability to reproduce not only the fundamental tones, but the overtones as well, which enables you to enjoy the true character and full beauty of the musical presentation.

Balance of Tone: Balance of tone is as vitally important to musical enjoyment as is the balance of color in a picture. For true musical enjoyment, the musical performance must be balanced properly with the high notes and low notes maintained in the same relationship as in the original performance. High fidelity components are designed to assure this proper tonal balance.

A hi-fi system consists of four basic units:

1. The record changer and cartridge.
   The record changer revolves the record. The pick-up arm contains a cartridge in which the needle is installed. The needle follows or "tracks" the record grooves, and with the cartridge, changes the vibrating paths in the grooves into small electrical voltage impulses.
2. Amplifier.
   This unit amplifies and builds up the final voltages produced by the cartridge into an amount of electrical energy capable of operating the loudspeaker or reproducer.
3. The Loudspeaker.
   This is the actual sound-reproducing unit. It converts the electrical energy delivered by the amplifier into sound waves.
4. Housing.
   This is the cabinet or cabinets that contain the record changer, amplifier, and loudspeaker. The loudspeaker should be in its own enclosure.

Stereophonic Sound: Stereo is a revolutionary new development in high fidelity. In stereo reproduction the sound takes on direction and depth to achieve remarkable realism. Stereo records and tapes have become extremely popular among those who want the ultimate in lifelike sound. A stereo system employs essentially the same components as any other high-fidelity system, but requires an additional amplifier (or dual-section stereo amplifier), an additional loudspeaker, and either a stereo phono cartridge or stereo tape player.

Radio Operating Hints

Tuning a Short-Wave set or an All-Wave set that covers the Short-Wave bands requires a procedure different from that of simply twirling the dial for Broadcast reception. It is necessary to keep in mind such factors as time difference between your own region and foreign countries, atmospheric conditions, and time of transmission schedules. Foreign Short-Wave stations frequently have available a number of different frequencies for transmission—and they shift from one frequency to another at different times of the day or in different seasons of the year. Some foreign stations transmit simultaneously on several frequencies; for example, the British Broadcasting Corporation transmits the identical program over stations GSB, GSC, GSD, and so on—each station being on a different frequency. Thus, if at any particular time conditions are such that you cannot pick up GSB, you may find that your set will bring in GSC because conditions are favorable for reception on its particular frequency. British stations—or other foreign stations transmitting in English—are easiest for the newcomer to identify. But you will soon learn to recognize foreign language stations, like "Ici Paris Radio Coloniale," which means "This is Paris." And other stations, too, have easily recognizable catch-phrases.

Since stations are crowded closely together on the Short-Wave portions of the dial, you must learn to tune very slowly and patiently in order to "pull in" the signals you want. This is a point which cannot be too strongly emphasized. Unless your Short-Wave set has provisions for bandspread (an arrangement making it possible to spread out stations over a larger dial scale area), you must not expect to tune in foreign stations as you would local stations. Tune very slowly in the area on the dial covering the frequency of the station you want.

If, after careful tuning, it appears to be impossible to tune in a specific station at one time, try again on another occasion—because when atmospheric conditions change, the station may "come in like a local." Remember that even the big commercial radio networks—with all of their costly and elaborate equipment (much of which is specially built and runs up into enormous sums of money)—sometimes cannot pick up programs from abroad scheduled for rebroadcast simply because atmospheric conditions are unfavorable.

Static—which simply means disturbance caused by atmospheric electricity—is a matter over which we have no control. This, of course, applies only to "true" static. "Man-made" static—disturbances caused by electric motors like those used in electric shavers, vacuum cleaners, elevators, mixers, etc.,—can be nearly eliminated by efficient filter devices attached to the source of the interference, although these filters are also sometimes useful when used between the electric outlet and the radio set. Battery operated sets are not usually affected by "man-made" static caused by the devices mentioned since such sets do not get their power from the electric line.

Amateur Radio

We now come to a subject which could be treated adequately only in far more space than we have available. This is the subject of Amateur Radio. Strictly speaking, an Amateur is a person who holds a Federal license to operate a transmitter on the radio bands restricted to non-commercial use. In order to obtain this license (issued by authority of the Federal Communications Commission) the prospective Amateur must meet a number of requirements which have been set up by the government.

There are five Amateur license classifications: Novice, Technician, General, Conditional and Extra Class. The Novice and Technician license exams make it particularly easy to get started in Amateur Radio. To obtain a Novice license it is only necessary to pass a simplified written exam covering theory and regulations and a code sending and receiving test of only five words per minute. The Novice license is good for one year; to retain Amateur privileges after that period it is necessary to pass the General Class exam. All Amateur licenses except the Novice license are good for five years and renewable without examination. The Technician exam consists of the same theory and regulation test as the General Class License, but a code sending and receiving speed of only five words per minute is required. The General Class exam consists of a written test on theory and regulations, as well as a code sending and receiving test at 13 words per minute. Those living 75 miles airline, or more, from an F. C. C. examining point may take the Conditional Class license exam. This exam is the same as the General Class exam, but is conducted at the residence of the applicant by two volunteer examiners. The Extra Class license requirements are comparable to that of commercial licenses. The exam consists of a written test on advanced theory and a code sending and receiving test of 20 words per minute. Novices and Technicians are permitted to operate on only a limited number of frequencies, while holders of the General, Conditional and Extra Class licenses have full privileges. At present, holders of the Extra Class license do not have any extra privileges, but this very advanced license is a mark of distinction and certainly something of which one can be very proud.

In all cases, the Amateur operator must be a citizen of the United States and the Amateur station must be operated on premises not owned or controlled by an alien. There is no age limitation—and so Amateurs range in age from 8 to 80.

Full details of the license requirements and the addresses of your nearest F.C.C. office can be obtained by consulting one of the many Amateur books or by writing to Allied. (In Canada, details of requirements may be obtained from the Canadian Radio Commission, Ottawa, Ontario.)

For purposes of radio administration, the continental United States is separated into ten districts. Amateur station call letters are based on this separation. In the first place the prefixes W and K were assigned to the United States by International radio convention. To one of these prefixes is added the number corresponding to the district number. W9 or K9, for example, are the prefixes for the district comprising the states of Illinois, Indiana and Wisconsin. Added to this prefix are two or three letters, identifying the individual station.

The U. S. districts are:

K1, W1—Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont.
K2, W2—New Jersey, New York.
K3, W3—Delaware, District of Columbia, Maryland, Pennsylvania.
K4, W4—Alabama, Florida, Georgia, Kentucky, North Carolina, South Carolina, Tennessee, Virginia.
K5, W5—Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, Texas.
K6, W6—California.
K7, W7—Arizona, Idaho, Montana, Nevada, Oregon, Utah, Washington, Wyoming.
K8, W8—Michigan, Ohio, West Virginia.
K9, W9—Illinois, Indiana, Wisconsin.
K0, W0—Colorado, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, South Dakota.

Code

Learning to transmit and receive the code should be an early step in the procedure of every one who intends to become an Amateur. The Continental International Code used in radio consists of short signals (called dots) and long signals (called dashes) which are about three times as long in duration as the short signals. The following table shows the code for letters of the alphabet, for numbers, and for common punctuation marks.

While the long and short signals are called dashes and dots, when heard over the air they sound like "dit" for the dots and "dah" for the dashes. The letter P, for example, sounds like "dit-dah-dah-dit." In learning the code, the letters should be memorized with the "dit-dah" sounds, not as "dot-dash."

We lack the space to say very much about the process involved in learning the code. Furthermore, it is adequately covered in several books for the Amateur. However, we can suggest that a "code-learning" device or "code practice set" of some kind be used. (An excellent, low-cost code practice oscillator is described on page 44. Pressing the key of a code practice oscillator produces a high-pitched tone very similar to the sound of code as it is transmitted. The beginner can thus associate the "dit-dah" combination of sound with each letter and fix the sound-combination firmly in mind. If two persons work the set together, they can learn to send and receive code in a short time.

Letters

● ▬	A	▬ ●	N
▬ ● ● ●	B	▬ ▬ ▬	O
▬ ● ▬ ●	C	● ▬ ▬ ●	P
▬ ● ●	D	▬ ▬ ● ▬	Q
●	E	● ▬ ●	R
● ● ▬ ●	F	● ● ●	S
▬ ▬ ●	G	▬	T
● ● ● ●	H	● ● ▬	U
● ●	I	● ● ● ▬	V
● ▬ ▬ ▬	J	● ▬ ▬	W
▬ ● ▬	K	▬ ● ● ▬	X
● ▬ ● ●	L	▬ ● ▬ ▬	Y
▬ ▬	M	▬ ▬ ● ●	Z

Numbers

● ▬ ▬ ▬ ▬	1	▬ ● ● ● ●	6
● ● ▬ ▬ ▬	2	▬ ▬ ● ● ●	7
● ● ● ▬ ▬	3	▬ ▬ ▬ ● ●	8
● ● ● ● ▬	4	▬ ▬ ▬ ▬ ●	9
● ● ● ● ●	5	▬ ▬ ▬ ▬ ▬	0

Punctuation

● ▬ ● ▬ ● ▬	Period
▬ ▬ ● ● ▬ ▬	Comma
● ● ▬ ▬ ● ●	Question Mark

The listing below shows frequency allocations assigned exclusively for Amateur use. C.W. (code) signals are permitted in all of these bands. Phone transmission is permitted in portions of them.

The Amateur bands are as follows:

3500-4000	KC	(80 meter band)
7000-7300	KC	(40 meter band)
14000-14350	KC	(20 meter band)
21000-21450	KC	(15 meter band)
28000-29700	KC	(10 meter band)
50-54	MC	(6 meter band)
144-148	MC	(2 meter band)
220-225	MC	(¾ meter band)

(There are also many Amateur micro-wave bands.)

The Amateurs of the world maintain several organizations, the most noted of which is the American Radio Relay League (A.R.R.L.). A full description of this group, its aims, and its operation is included in the A.R.R.L. Handbook (see List of Books, page 30). Amateurs have, on hundreds of occasions, particularly during times of disaster, rendered immeasurable service. The 1936 Ohio Valley flood, the Long Island and New England hurricanes of 1938, the Florida and Gulf Coast hurricanes in 1947, Louisiana's 1957 hurricane, and the 1958 Wisconsin tornado, are but a few of the times that Amateurs have maintained contact with the rest of the country when almost all other facilities have failed. The newspapers frequently tell of how lives of persons in isolated localities are saved by Amateur radio communications.

But even aside from times of disaster and heroism, Amateurs are constantly active to improve the art of radio and to further fellowship and good will. The radio-builder and experimenter who passes beyond the beginning stages can well set as his goal the operation of his own Amateur station.

Amateurs played a very important role in our country's victory in World War II. At the beginning of the war Amateurs were an immediate source of highly trained urgently needed radio operators. In addition, they rendered great service in emergency civilian work.

As mentioned before, there are several handbooks and manuals available which give complete information on how to become a licensed amateur radio operator. An excellent education in radio may be obtained from them, as they adequately cover theory, operation, and actual construction of many "rigs"—from small low-cost sets to very elaborate ones. They are revised periodically, bringing up to date many circuits on transmitters and receivers which it would be impossible to cover within the pages of this booklet.

The American Radio Relay League also publishes the popular monthly periodical, QST. Another popular Amateur magazine is CQ. While most of the articles are for the more advanced Amateur, a good many are of special interest to the beginner.

The following books are suggested as reference works for the student of radio, and as sources of further information for the advanced radio builder. All of these books and many more may be purchased from Allied Radio.

Allied's Dictionary of Radio Terms. Over 3500 concise, easy-to-understand definitions of commonly used words in Radio, Electronics and Television. Fully illustrated. 80 pages.

Allied's Radio Circuit Handbook. Ideal for the student and experimenter. Shows typical radio circuits with explanation of their functions. In addition there are 16 extra diagrams of basic radio circuits with explanation of their use in complex radio design.

Allied's Electronics Data Handbook. Edited by Nelson M. Cooke, Lieutenant Commander, U. S. Navy. Handbook of formulas, data, standards, tables and charts used in the solution of everyday problems in radio and electronics.

Amateur Radio Relay League: *The Radio Amateur's Handbook.* The official handbook of the A. R. R. L., covering every aspect of Amateur radio.

Amateur Radio Relay League: *Radio Amateur's License Manual.* Standard reference for the radio enthusiast in preparation for FCC license. Covers all classes of Amateur licenses currently available. Includes rules and regulations and typical examination questions with answers.

Amateur Radio Relay League: *How to Become a Radio Amateur.* Outlines steps required to become a radio Amateur. Elementary theory instruction plus instructions for simple station equipment.

Wiley Publications: *Principles of Radio.* By Henney and Richardson. This well-illustrated 655-page book provides an excellent theoretical background. Thoroughly covers electrical fundamentals and radio theory. Includes laboratory experiments.

Editors and Engineers: *The Radio Handbook.* Covers radio building and operating. An Amateur essential. Diagrams and instructions for building everything from a 1-tube receiver to a 1 K.W. transmitter.

Radio Corporation of America: *R.C.A. Tube Manual.* Complete technical specifications on all R.C.A. receiving type tubes.

For prices of above, and for lists of other useful books, consult your current Allied catalog.

List Of Symbols and Abbreviations

As you read circuit diagrams or radio magazines and books, you will frequently run across a good many abbreviations or symbols for radio terms. We believe that even the radio beginner ought to know the meanings of some of the more common abbreviations in general use. The list below covers those most commonly used.

AC —Alternating current
AF —Audio frequency
AFC —Automatic frequency control
AM —Amplitude modulation
amp —Ampere
Ant. —Antenna
AVC —Automatic volume control
BC —Broadcast
BFO —Beat frequency oscillator
C —Capacity
CW —Continuous wave (refers to *code* transmission)
db —Decibel
DC —Direct current
DX —Long distance
E —Symbol for volts
E_p —Average plate voltage (D.C.) of a tube
E_f —Filament or heater voltage of a tube
FM —Frequency modulation
EMF —Electromotive force (voltage)
Gnd. —Ground
Ham —Licensed Amateur
HF —High frequency
Hy —Henry (unit of measurement for inductance)
I —Symbol of current in amperes
I_p —Average plate current (D.C.) of a tube
IF —Intermediate frequency
kc —Kilocycle (1000 cycles)
KW —Kilowatt (1000 watts)
Meg —Megohm (1,000,000 ohms)
Ma —Milliampere (1/1000 amperes)
mc —Megacycle
Mil —One-thousandth
Mhy —Millihenry
Mike —Microphone
mfd —Microfarad (1/1,000,000 of a farad)
mmf —Micro-microfarad (1/1,000,000 of a microfarad)
MU —Amplification factor of a tube
Ω —Ohm
PA —Public Address
'phone —Radiotelephone (voice transmission)
R —Resistance
RF —Radio frequency
RL —Plate load resistance of a tube
RMS —Root Mean Square
SG —Screen grid
Super —Superheterodyne (a type of radio circuit)
SW —Short wave
SWL —Short wave listener
TRF —Tuned radio frequency (a type of radio circuit)
UHF —Ultra high frequency
VHF —Very high frequency
W —Watt
Xmitter —Transmitter
Xtal —Crystal
Z —Symbol for impedance

Conversion Table

1 Ampere = 1,000,000 microamperes
1 Ampere = 1,000 milliamperes
1 Cycle = .000001 megacycles
1 Cycle = .001 kilocycles
1 Farad = 1,000,000,000,000 micromicrofarads
1 Farad = 1,000,000 microfarads
1 Henry = 1,000,000 microhenrys
1 Henry = 1,000 millihenrys
1 Kilocycle = 1,000 cycles
1 Megacycle = 1,000 kilocycles
1 Megohm = 1,000,000 ohms
1 Microampere = .000001 amperes
1 Microfarad = .000001 farads
1 Microhenry = .000001 henrys
1 Micromicrofarad = .000000000001 farads
1 Microvolt = .000001 volts
1 Milliampere = .001 amperes
1 Millihenry = .001 henrys
1 Milliohm = .001 ohms
1 Millivolt = .001 volts
1 Ohm = .000001 megohm
1 Volt = 1,000,000 microvolts
1 Volt = 1,000 millivolts

Test Equipment

In addition to the mechanical tools needed for radio construction and the soldering gun or iron to fasten wires securely together, the radio builder will find that electrical test instruments will also prove extremely helpful. Such instruments will enable the radioman to measure the voltages in the circuit, to check resistances and circuit continuity, to test tubes and transistors and, in general, to reveal whether or not a circuit is functioning properly. After the necessary background and experience have been acquired, a radioman will be able to use test instruments to repair radios, television receivers, motors and the many other electrically-powered devices that are found in the modern home.

For the person who is just starting in the radio field, the most useful test instrument to acquire is a volt-ohm-milliameter. Commonly referred to as a VOM, this instrument will measure a-c and d-c voltages, a wide range of resistances and d-c current. Sometimes, a-c current can be measured, too. No external source of power is required; however, a small dry cell which is mounted inside the instrument case is required for the resistance checks.

The principal governing factor in the cost of a VOM is its sensitivity, expressed in ohms-per-volt. Knight-Kit VOM kits with values of 1,000 and 20,000 ohms-per-volt are available, with the higher value signifying a more sensitive meter movement and consequently costing more. VOM's are also available fully constructed, although kits tend to be considerably lower in cost. Furthermore, they come complete with detailed instructions on how they should be constructed so that anyone who is able to solder wires will have no trouble building the kits.

Closely allied to VOM's are vacuum-tube voltmeters, commonly called VTVM's. These are usually a-c powered, although battery operated VTVM's are also available. A Knight-Kit VTVM kit will permit more extensive and more accurate measurements to be made than a VOM and for that reason is perhaps more widely used by service technicians in their work. However, there is a wide range of measurements which VOM's and VTVM's perform equally well and for the beginner either one will do.

The second basic test instrument is the tube tester or checker. With it, the radioman will be able to test all types of receiving tubes to determine their condition; whether they are good or bad or simply weak. A tube tester is important because tubes are, by far, the most common cause of circuit failure and are the first item to be checked when difficulty is encountered.

A Knight-Kit tube tester kit will not only permit testing conventional receiving tubes but television picture tubes as well. Some testers are devoted solely to tube checking, while others contain such supplementary features as transistor testing, selenium rectifier measurements, continuity checks, etc. In the beginning it is probably best to start off with a good, reliable unit which is relatively inexpensive. After the radio builder has had the experience of working with a number of circuits, he will then be in a better position to select a more expensive instrument, if this is felt necessary.

With the two instruments described above, the radioman will be able to perform 80 percent of all the measurements he will be called upon to make. For the remaining 20 per cent, other test instruments are needed; some of the more important of these are described briefly below.

Oscilloscopes: These are instruments which produce a visual image of the current or voltage waveforms present in a circuit. The picture is developed on the face of a cathode-ray tube which is essentially identical to the picture tube contained in a television receiver. A Knight-Kit oscilloscope is very useful in checking any circuit where the form of the voltage or current is distinctive and where deviations from the normal shape will disrupt operation noticeably. This is particularly true of television receivers.

Signal Generators: A signal generator develops signals of specific frequency. Such signals, when applied to a circuit, reveal whether the circuit is functioning normally or not. A signal generator can be looked upon as a miniature broadcast station which enables the technician to check a circuit (or a receiver) at his convenience and in the manner that he wishes. These instruments also provide stronger signals at the receiver than broadcast stations normally produce.

Generators are available in several different forms, such as the Knight-Kit R.F. signal generator, the Knight-Kit sweep generator and the Knight-Kit audio generator.

Resistance-Capacitance Testers: These instruments measure resistance and capacitance values and, in the case of capacitors, also indicate whether the units are defective or not.

Signal Tracers: Knight-Kit signal tracers are designed primarily for the servicing of radio receivers and audio equipment. They trace the signal through the various stages of a receiver, indicating where the signal level either decreases sharply or is lost completely. They also come equipped with a loudspeaker and several audio stages so that they can serve as a general purpose audio amplifier.

Representative examples of the equipment discussed are shown on the following page. All of these instruments plus many more are available from Allied.

Some Interesting Circuits

On the pages that follow we have included diagrams and construction notes on a number of circuits of special interest to radio builders. The most versatile of these is described on pages 33-35—the Knight-Kit Lab Kit. The circuits were carefully designed so that a minimum of parts is used in a maximum of circuits. The kit is recommended for all beginners. It also makes excellent classroom material for schools. You'll find this complete kit listed in the kit section of Allied's catalog.

Other features of this kit are the use of low voltages and a wired-in power cord as safety factors, separate tubes for each function for a clearer understanding of what each tube does, single control for simplicity, and careful design that makes it possible for anyone to follow the circuit in building these units and enjoy good performance from each.

The circuit of the "Span Master" on pages 36 and 37, provides the best performance obtainable from only a few tubes. It is carefully designed, using modern tubes, and is a real "DX getter."

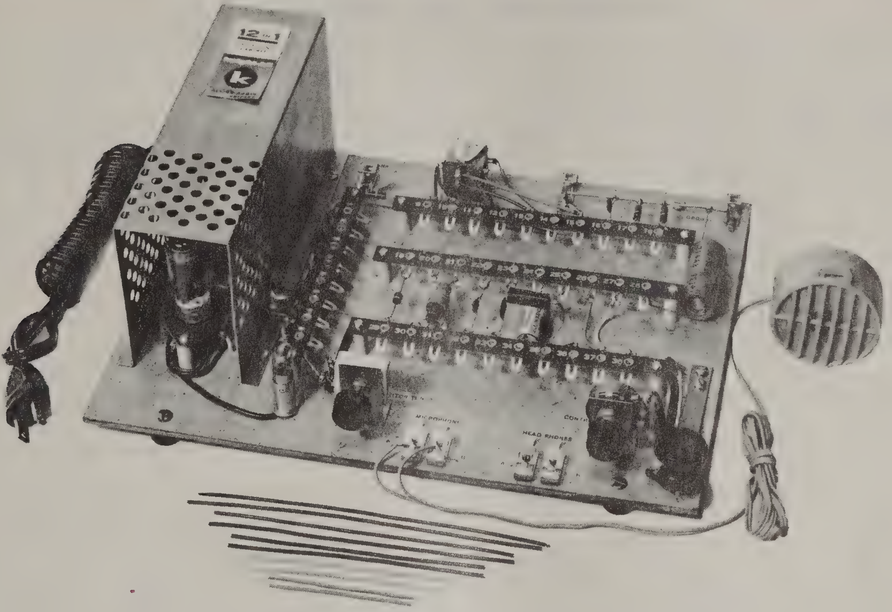
In addition to the circuits described on these pages, many more—of all types—will be found in construction articles in radio magazines and other handbooks. Also, every Allied catalog devotes a number of pages to listings of "build-your-own" kits. The beginner is certain to find many projects of interest. Construction of test instrument kits provides an excellent means for learning the functions and use of test units, and saves money on the actual cost of the instruments.

The Allied catalog also lists numerous diagrams and blueprints. Each diagram contains complete construction data, schematic and pictorial diagrams and a list of parts required to build the set.

It might be pointed out here that it is not absolutely necessary to use the exact parts as specified in a construction article. As long as parts have the same electrical specifications, good results can be expected.

The construction notes on the following circuits are based on actual laboratory construction of these sets. In each case, the beginner should follow the instructions faithfully. Failure to do so may result in poor operation—or total lack of operation—of the circuits described. In all cases, both pictorial and schematic diagrams have been included to clarify as much as possible the exact procedure to be followed in wiring.

The pictorial diagrams on the following pages show you the actual placement of components in the completed units. Knight-Kits are supplied with the chassis; panels are completely formed, punched and drilled. This simplifies the construction of a kit. All parts are selected, matched components—to insure best performance, maximum dependability, and ease of construction. Few tools are needed at first. In general, the only tools required are a soldering iron, a screwdriver and a pair of pliers. It will probably be easier for the beginner to follow a pictorial rather than a schematic diagram. However, when constructing a kit, both the pictorial and schematic diagrams should be followed. In this way you will become familiar with the various symbols which represent radio components used in a circuit. In following your pictorial or schematic diagram cross off on the diagram the corresponding wire as it is connected in the circuit under construction. This will eliminate omissions in the wiring of the kit. If the foregoing points are kept in mind, the builder will have no difficulty in building the kits which are described on the following pages.



knight-kit 12-In-1 Electronic Lab Kit

The lab kit was designed to demonstrate how most electronic circuits use the same basic parts. The circuits are assembled "breadboard" fashion for easy assembly and for simplified circuit tracing. Once the basic parts assembly is completed, one circuit after another can be built by simply changing wiring connections. Numbered terminals help the beginner.

The safety-type power supply reduces all voltages on the board to 25 volts or less. The kit can be operated from any standard AC wall outlet.

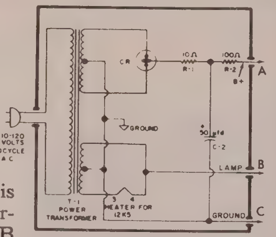
Listed below are 12 circuits which can be built with the Knight-Kit 12-In-1 Electronic Lab Kit.

1. BROADCAST RECEIVER. Tunes standard AM broadcasts from 550 to 1300 kilocycles.
2. AUDIO AMPLIFIER. Demonstrates how the output voltage from a microphone is amplified.
3. LIGHT-CONTROLLED OSCILLATOR. Produces an audio note in headphones. The tone varies with light intensity on the photocell.
4. VOICE-OPERATED RELAY. In this circuit your voice in the microphone turns the lamp on.
5. WIRELESS BROADCASTER. Miniature transmitter — talk through any radio in the house.
6. ELECTRONIC FLASHER. This cycling device flashes the indicator lamp at regular intervals.
7. CAPACITY-OPERATED RELAY. This circuit uses the electrical properties of the human body to trip a relay controlling an indicating lamp.
8. WIRELESS CODE PRACTICE OSCILLATOR. As above, but sends dots and dashes (code).
9. CODE PRACTICE OSCILLATOR. The circuit develops an audio note that can be heard in headphones each time the telegraph key is pressed.
10. PHOTOELECTRIC RELAY. In this circuit, a relay wired to control an indicating lamp, is actuated by the beam of an ordinary flashlight.
11. ELECTRONIC SWITCH. This circuit is similar to those used in rain detectors, liquid level indicators and salt solution testers. The presence of liquid in the detecting element turns the lamp off.
12. ELECTRONIC TIMER. Electronically times operation of relay controlling an indicating lamp.

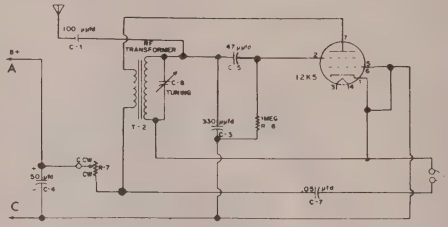
The Knight-Kit 12-In-1 Electronic Lab Kit is listed in the kit section of Allied's catalog.

knight-kit 12-In-1 Electronic Lab Kit

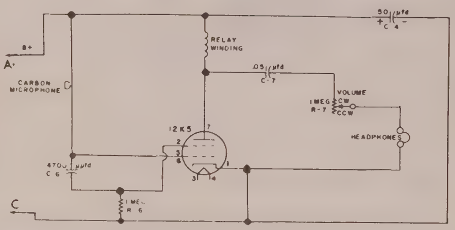
POWER SUPPLY
OF 12-IN-1 KIT



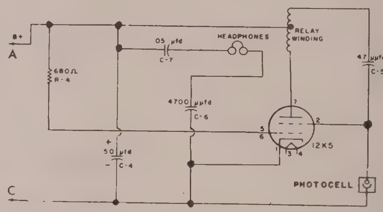
The power supply is common to all circuits. Points A, B and C connect to corresponding points in the 12 circuits. Point B is not always used.



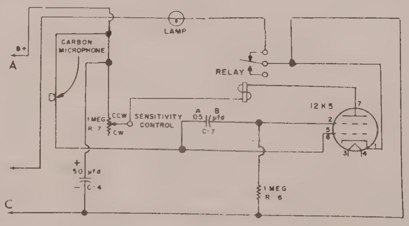
Circuit No. 1
AM BROADCAST RECEIVER



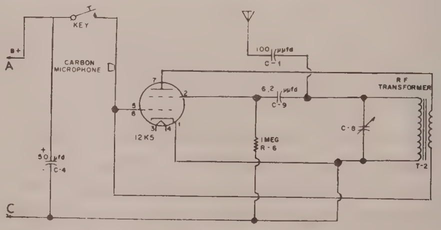
Circuit No. 2
AUDIO AMPLIFIER



Circuit No. 3
LIGHT-CONTROLLED OSCILLATOR

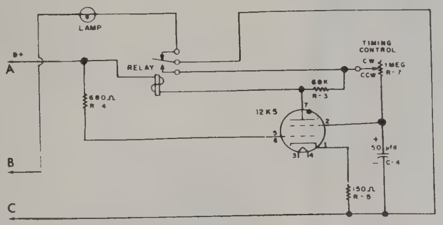


Circuit No. 4
VOICE-OPERATED RELAY

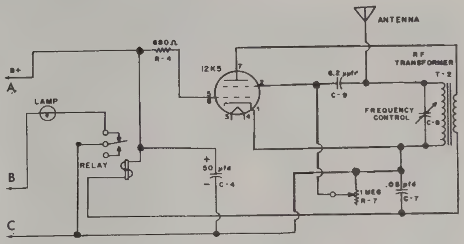


Circuit No. 5
WIRELESS BROADCASTER

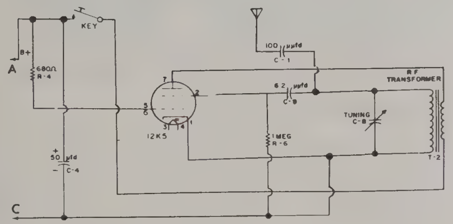
knight-kit 12-In-1 Electronic Lab Kit



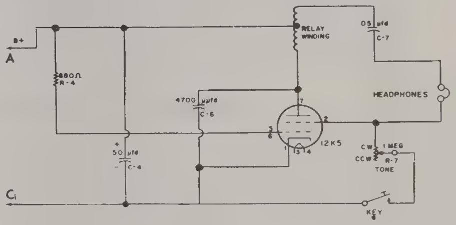
Circuit No. 6
ELECTRONIC FLASHER



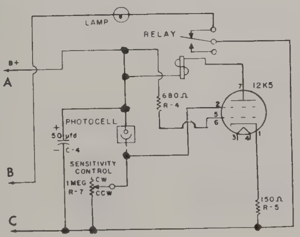
Circuit No. 7
CAPACITY-OPERATED RELAY



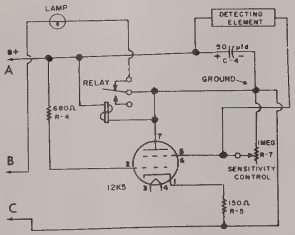
Circuit No. 8
WIRELESS CODE PRACTICE
OSCILLATOR



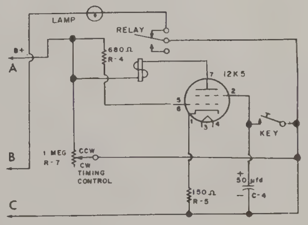
Circuit No. 9
CODE PRACTICE OSCILLATOR



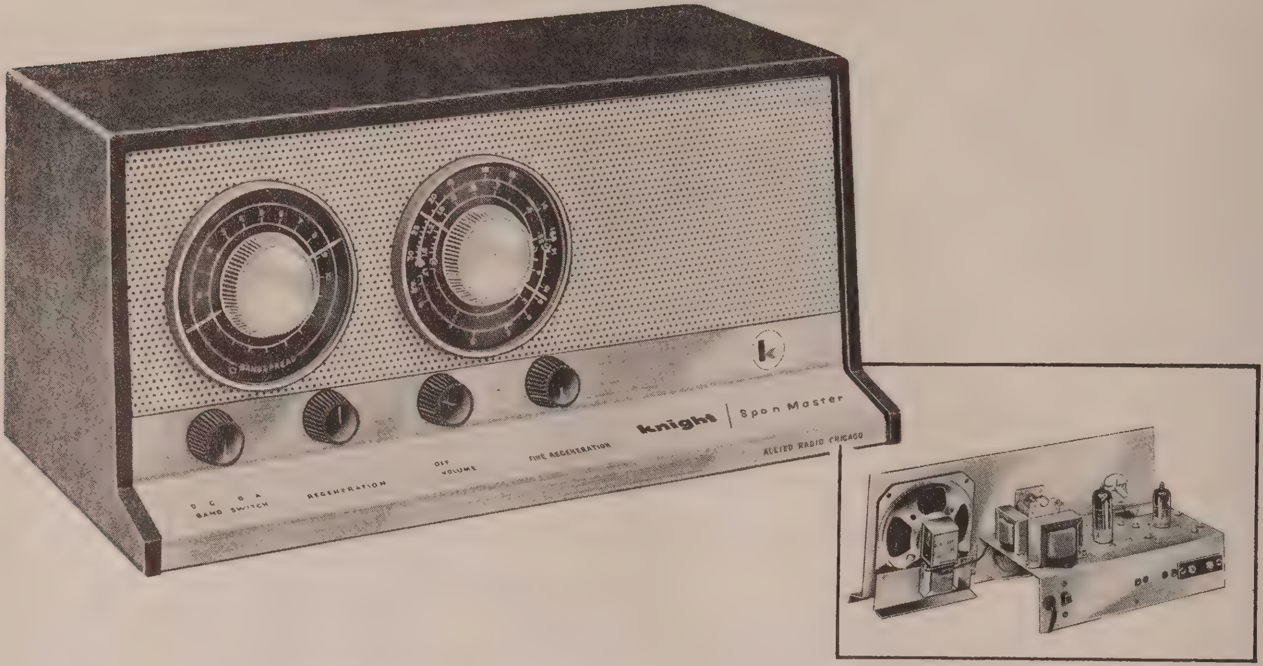
Circuit No. 10
PHOTOELECTRIC RELAY



Circuit No. 11
ELECTRONIC SWITCH



Circuit No. 12
ELECTRONIC TIMER



knight-kit "Span Master" 4-Band Receiver Kit

The Knight-Kit "Span Master" is an extremely versatile, highly sensitive, 4-band regenerative receiver for reception of standard AM and world-wide short-wave broadcasts. Although it incorporates important "plus" features to assure easy operation and loud, clear reception, it can easily be assembled by the newcomer to radio.

Its highly efficient regenerative circuit includes many refinements that contribute greatly to its performance and operating convenience. One of these refinements is bandswitching which permits changing over from broadcast band to shortwave reception simply by turning a knob on the front panel. Another refinement is an additional audio amplifier stage which provides loudspeaker reception of the weaker, as well as the stronger broadcast band and shortwave stations. The "Span Master" has a transformer-type power supply to permit more efficient use of tubes for optimum sensitivity.

A 4″ speaker, included with the kit, is mounted directly behind the front panel. For private listening, or when stations are very weak, headphones may be plugged in at the rear of the set. A switch permits shutting off the speaker.

There are four bandswitch positions. A convenient knob gives you instant choice of any of four bands, providing continuous coverage from 540 kc to 30 mc. You will be able to tune in American and foreign broadcasts, amateurs, ships at sea, code stations sending news and radiograms, as well as many other exciting transmissions on the short wave frequencies.

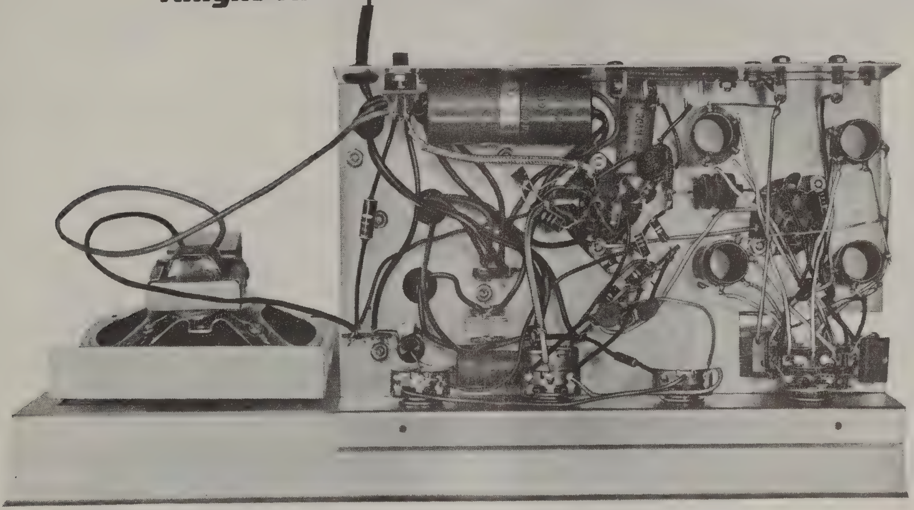
In addition to the main tuning dial the "Span Master" has a band-spread tuning dial which separates the crowded shortwave stations to simplify tuning.

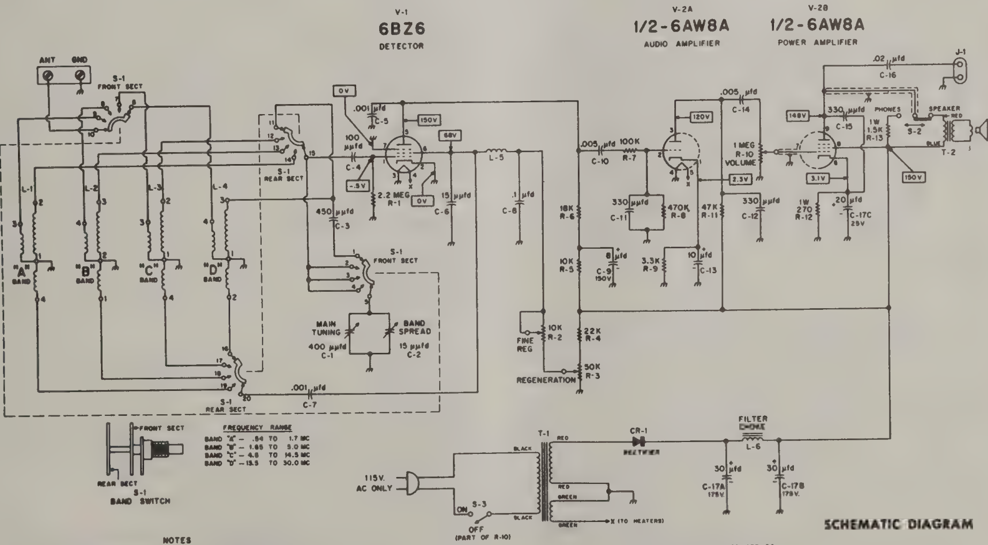
Tubes employed are a 6BZ6 detector, 6AW8A audio output, and a highly efficient selenium rectifier. The 6AW8A tube is actually equal to two tubes in one envelope; one half serves as an audio amplifier and the other as power amplifier.

The "Span Master" is transformer powered and is for operation from 110-125 volts AC—it may be plugged into any convenient wall outlet.

This fine, low-cost receiver, complete with handsome case, tubes, pre-punched chassis, speaker, wire and solder, all parts, a listing of stations throughout the world, and an informative manual containing step-by-step instructions, is listed in the kit section of the Allied catalog.

knight-kit "Span Master" 4-Band Receiver Kit





FREQUENCY RANGE

BAND "A" —	.54	TO	1.7 MC
BAND "B" —	1.65	TO	5.0 MC
BAND "C" —	4.8	TO	14.5 MC
BAND "D" —	13.5	TO	30.0 MC

SCHEMATIC DIAGRAM

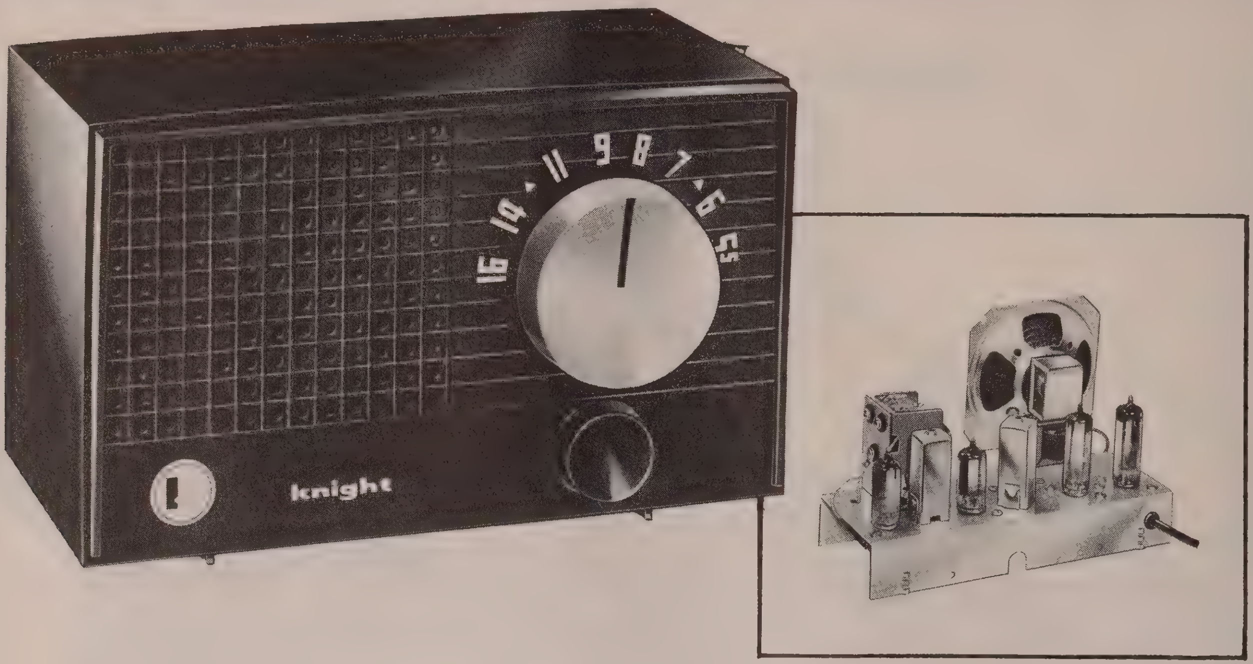
NOTES

RESISTORS INDICATED IN OHMS
K=1,000 OHMS
MEG = 1,000,000 OHMS

CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

VOLTAGE MEASUREMENTS ARE DC FROM POINTS INDICATED TO CHASSIS.

MEASUREMENTS MADE WITH A VTVM



knight-kit "Ranger III" AC-DC Superhet Kit

The Knight-Kit "Ranger III" is an AC-DC type radio receiver employing four tubes and a rectifier in a modern, superheterodyne circuit. Its circuit design assures sensitive, selective reception of the standard AM broadcast band. Among the special features included in the "Ranger III" are a built-in loop antenna; printed audio coupling circuit; and automatic volume control (AVC) to reduce "blasting" on strong stations and fading on weak stations. These advantages are achieved without complex circuitry, and in fact, this receiver can easily be assembled by beginners.

The "Ranger III" occupies minimum space and serves as an excellent radio for kitchen, den or bedroom. All circuit components fit on a very small chassis. The complete kit, available at Allied Radio, includes a handsome, black plastic cabinet with contrasting white knob and dial.

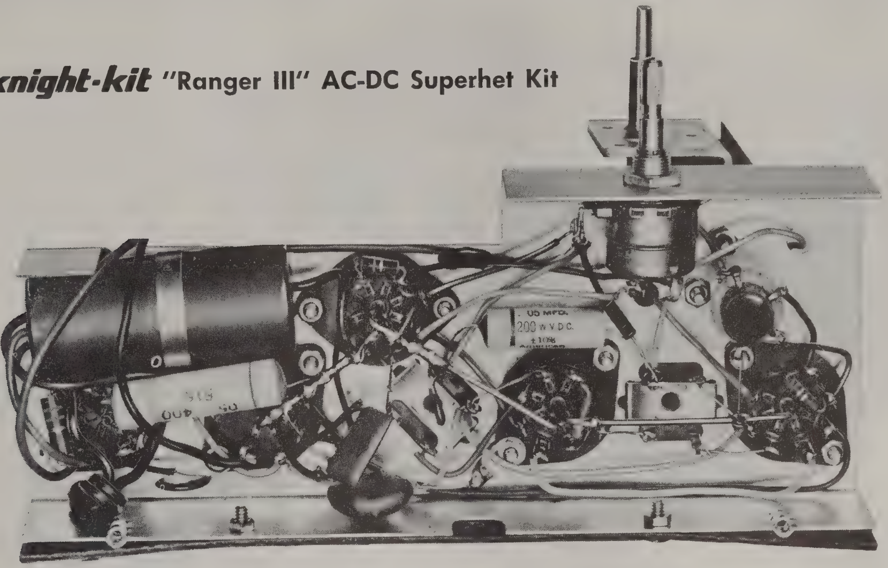
This carefully designed receiver differs in one important respect from the receivers previously described. It employs a superheterodyne circuit, which means that its tubes include a mixer-oscillator (converter) and IF (intermediate frequency) amplifier. While this type of circuit requires the use of more tubes and components than the regenerative-type receiver, it offers the advantage of exceptionally high selectivity, plus higher efficiency for greater amplification.

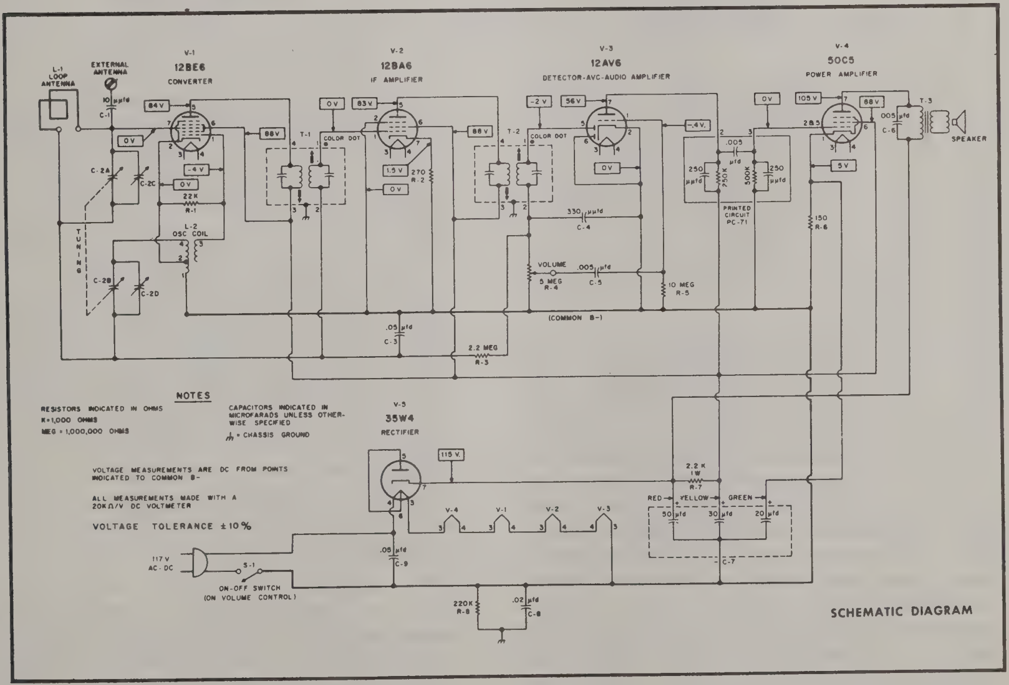
Tubes used are a 12BE6 converter, 12BA6 IF amplifier, 12AV6 detector-AVC-audio, 50C5 audio output; rectifier is a 35W4. The loop antenna used with the "Ranger III" will provide excellent local broadcast reception during the day, and by tuning between the stronger broadcast stations during the evening hours you will be able to obtain cross-country reception. For even greater sensitivity, the circuit includes provisions for the use of a long-wire outdoor antenna.

The beginner will certainly obtain a great deal of valuable background in radio circuitry by building a receiver of this type. The superheterodyne circuit is used in all advanced-type receivers available today, and even television receivers operate on the superheterodyne principle.

The "Ranger III", complete with tubes, all parts, punched and drilled chassis, pre-tuned IF transformers, cabinet and step-by-step instructions, is listed in the kit section of the Allied catalog.

knight-kit "Ranger III" AC-DC Superhet Kit





NOTES

RESISTORS INDICATED IN OHMS
K=1,000 OHMS
MEG = 1,000,000 OHMS

CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED

⏚ = CHASSIS GROUND

VOLTAGE MEASUREMENTS ARE DC FROM POINTS INDICATED TO COMMON B-

ALL MEASUREMENTS MADE WITH A 20KΩ/V DC VOLTMETER

VOLTAGE TOLERANCE ±10%

SCHEMATIC DIAGRAM

knight-kit
Amateur Communications Receiver Kit

A few years ago, none but the most experienced radio builders would attempt construction of a receiver of this type. Today, modern engineering techniques combined with electronic "know how" have produced a precision receiver that anyone with a little kit building experience can assemble. The results are a professional-quality receiver equal or superior in performance to many factory wired receivers.

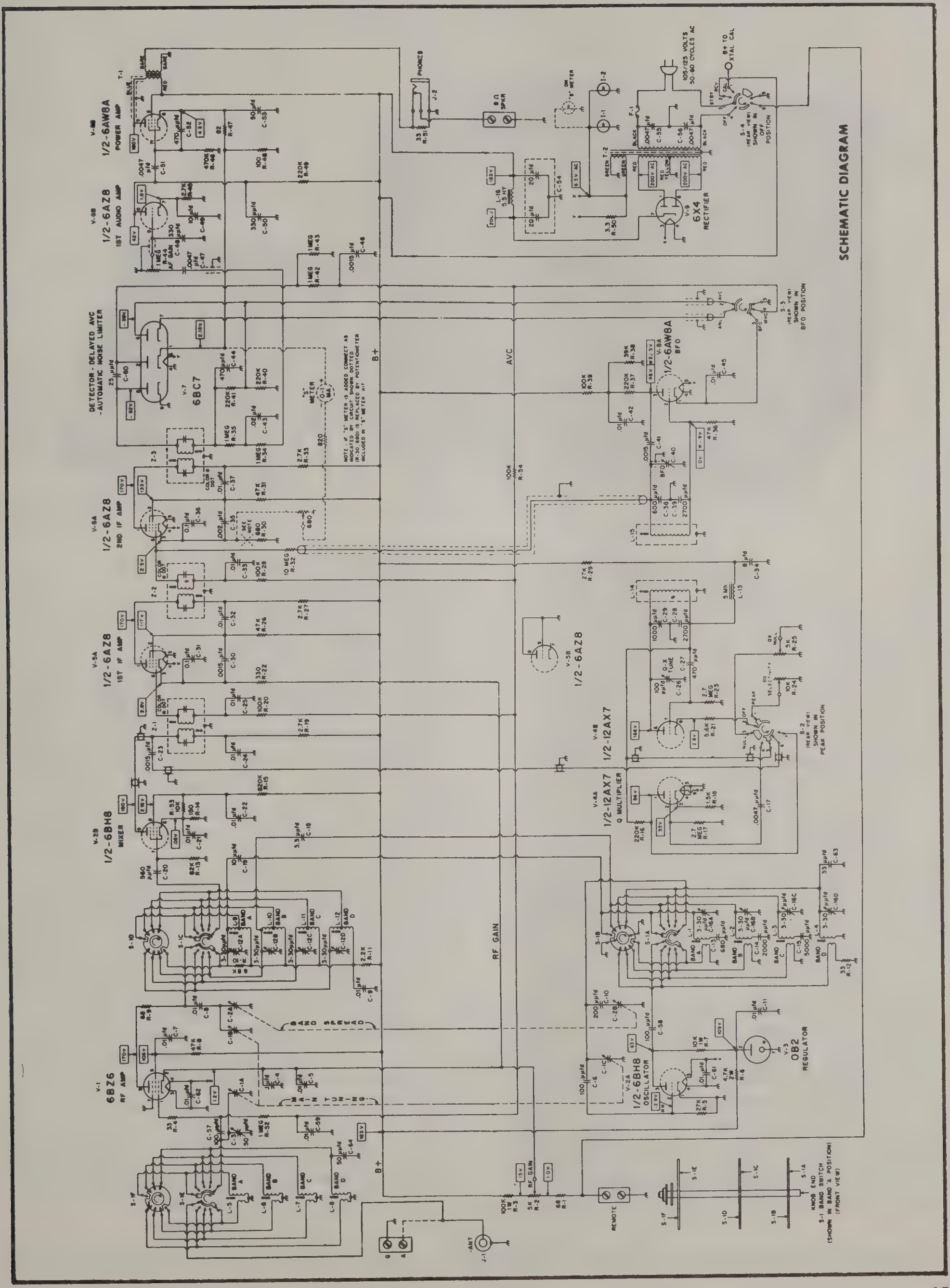
Designed to meet the high standards demanded for top-notch amateur performance, this receiver has every deluxe feature required for high sensitivity and razor-sharp selectivity. The tuning range is from 540 kc through 30 mc in four ranges. In addition to coverage of all amateur bands from 80 to 10 meters, this receiver also tunes foreign and domestic standard, medium and shortwave broadcasts. It's an ideal receiver for shortwave listeners as well as amateurs. Tuning of the crowded shortwave is simplified through the use of a separate "bandspread" tuning capacitor. The bandspread dial is calibrated for amateur frequencies from 80 through 10 meters. Civil defense frequencies are clearly marked. Both the main and the bandspread tuning have smooth operating vernier dials.

Other deluxe features of this receiver include a highly effective noise limiter and a built-in Q-multiplier which peaks desired signals and nulls undesired signals and interference. A constant running high-frequency oscillator with voltage regulated B+ supply, and an extra-heavy chassis contribute to the rock-like stability of the receiver.

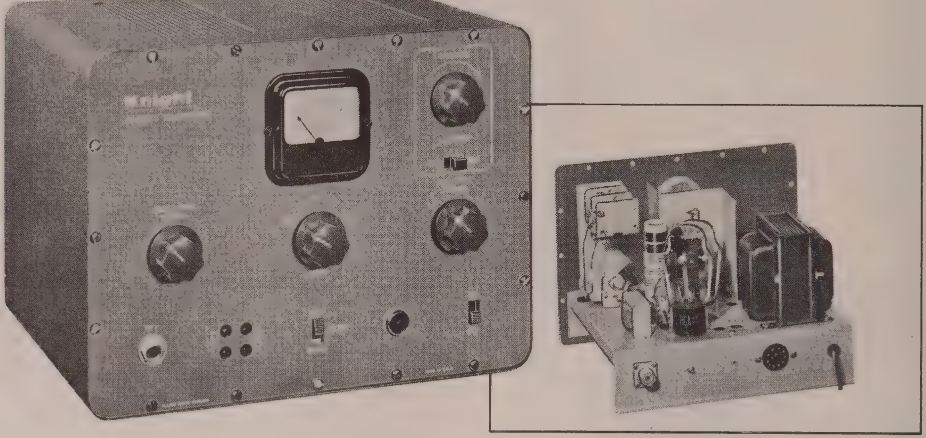
Assembling the Knight-Kit amateur communications receiver is simplified through use of printed circuit boards and a unique printed circuit bandswitch. Use of printed circuits eliminates all complex wiring and the problems of component placement and lead dress. You are assured of a completed unit which will perform as well as the original pilot model.

Use of multi-purpose tubes in this 7 tube superhet circuit provides performance equivalent to that of 11 tube receivers.

The amateur communications receiver kit, complete with cabinet, all tubes, parts, and detailed assembly instructions with large pictorial and schematic diagrams is listed in Allied's catalog. A matching speaker kit and an "S" meter kit which mounts in the panel of the receiver are also listed.



knight-kit Amateur Communications Receiver Kit



knight-kit 50-Watt CW Transmitter Kit

The versatile, highly dependable Knight-Kit 50-watt CW (code) transmitter is "made to order" for the Amateur newcomer. It's very low in cost; it covers all Amateur bands from 80 through 10 meters; it puts out sufficient power for coast-to-coast as well as foreign contacts; it works well with almost any type of antenna; it can easily be used with a modulator should you wish to go on phone (use a microphone); its straightforward, time-tested circuit is easy to build and easy to adjust.

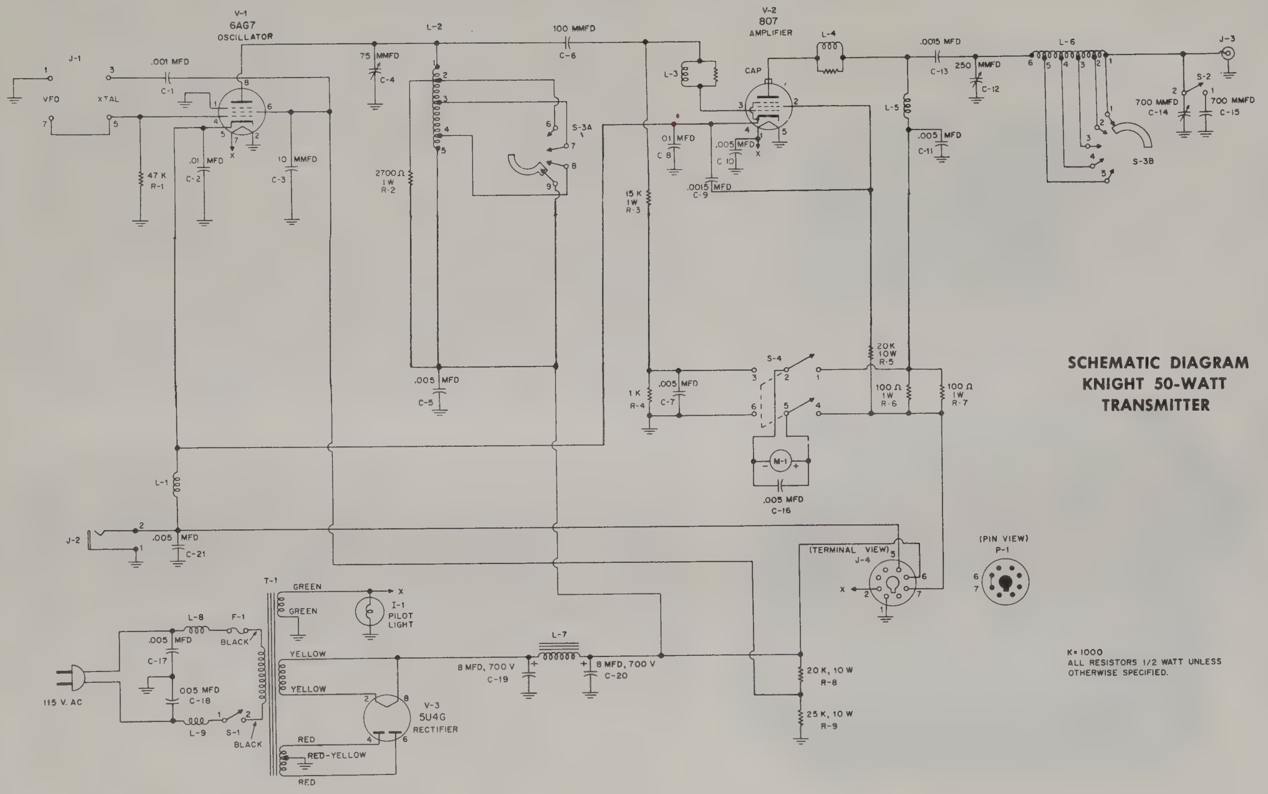
An Amateur license, issued by the FCC (Federal Communications Commission), is always required when operating transmitting equipment. The Novice Class Amateur license is particularly easy to obtain (see Amateur Radio on page 22). Novice Amateurs are permitted to operate on CW only on the 15, 40 and 80 meter bands. However, you will be ready to operate on any other of the popular Amateur bands with this transmitter just as soon as you advance to a General Class license. In addition, convenient terminals at the rear of the transmitter, make it easy for you to connect an external modulator should you wish to use a mike when you graduate from the Novice to the General Class license.

Tubes used in the Knight-Kit 50-watter are a 6AG7 crystal oscillator, 807 amplifier and 5U4G rectifier. Only a few crystals are required for all-band operation and changing from one band to another is simply a matter of turning the band-switch knob and, in some cases, plugging a different crystal into the crystal socket on the front panel.

The Knight-Kit transmitter incorporates features for the suppression of harmonic radiation in order to prevent TVI (interference to TV sets). These features include: Copper-finished chassis and cabinet interior; metal-to-metal seals at all metal junctions; filtering; shielding; and by-passing. The transmitter also includes a pi-network antenna output circuit which further aids in the suppression of harmonic radiation. The pi-network is a very valuable feature, since it permits using almost any random length of wire as an antenna.

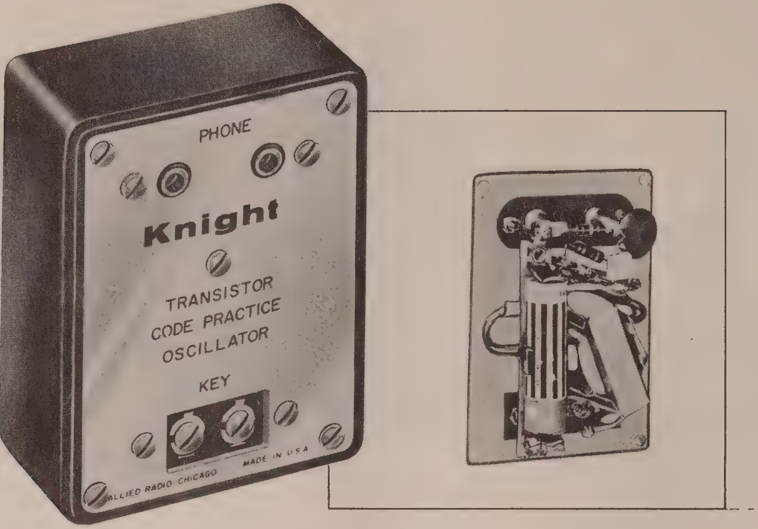
A handsome metal cabinet, supplied with the kit, gives the transmitter a professional, factory-built appearance. A built-in power supply permits operation from 110-120 volts, 50-60 cycle AC.

The Knight-Kit transmitter in kit form, with all parts, tubes, wire, solder and step-by-step instructions, is listed in Allied's catalog. Crystals and key, available separately are also listed.



SCHEMATIC DIAGRAM
KNIGHT 50-WATT
TRANSMITTER

K= 1000
ALL RESISTORS 1/2 WATT UNLESS
OTHERWISE SPECIFIED.



knight-kit Transistorized Code Practice Kit

One of the most useful projects the aspiring Amateur can undertake is the construction of a code practice oscillator.

As indicated on page 22 of this handbook, it is necessary under FCC regulations to be able to send and receive the International Morse Code to obtain an Amateur license. A speed of 5 words per minute is required for the Novice and Technician Class licenses and 13 words per minute is required for the General and Conditional Class licenses.

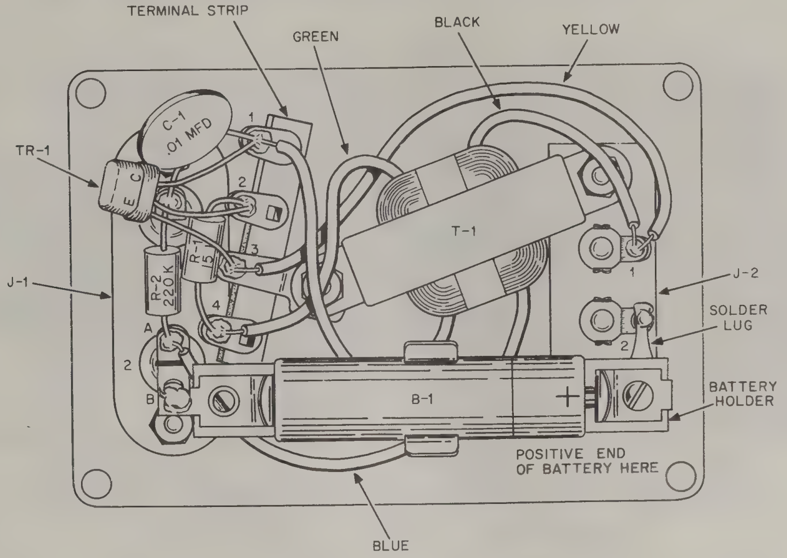
The Knight-Kit transistorized code practice oscillator uses only a few components, is exceptionally easy to build, and operates for months and months on a single penlight-type flashlight cell. By using this oscillator, and taking turns with a partner in sending and receiving, you will soon acquire sufficient skill to pass the FCC code examination.

The oscillator will also be very helpful to you even after you have obtained your Amateur license. You will be able to continue to use it for additional code practice to further increase your sending speed and to improve on sending clarity.

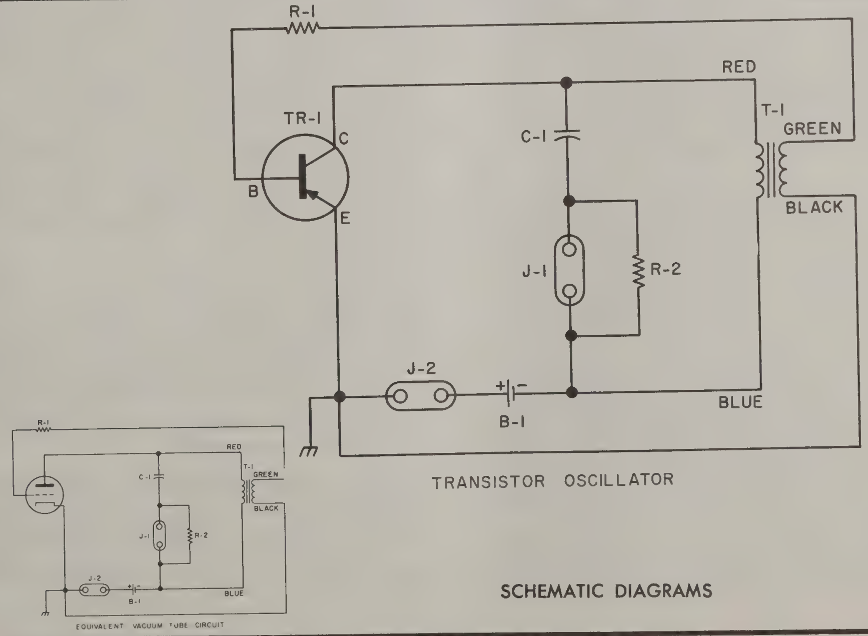
The Knight-Kit oscillator produces an audio signal which is almost identical in tone to the code sent during the license exam, as well as that actually transmitted by Amateur and commercial CW (code) stations. The heart of this oscillator is a transistor which performs all the functions of a tube, but at an extremely small fraction of the power. Since a transistor does not use a filament, no power is wasted in heat and remarkable battery economy is achieved. Tests have shown that the oscillator will operate for 30 weeks continuously an a single cell. However, under normal usage, it should operate for the shelf life of the cell. In other words, you will have long learned the code before even a single battery replacement is necessary.

Convenient pin jacks are located on the front panel to permit plugging in a single headphone set, or a pair of headphone sets (wired in series) so that both you and your partner can listen together. Any headphones having an impedance of 1000 ohms or more may be used. Two screw-type terminals for connnecting a key are also located on the panel.

The Knight-Kit transistorized code practice oscillator, with all parts, black bakelite case, anodized aluminum panel and easy-to-follow assembly instructions, is listed in the kit section of the Allied catalog. Headphones and key, available separately, are also listed.



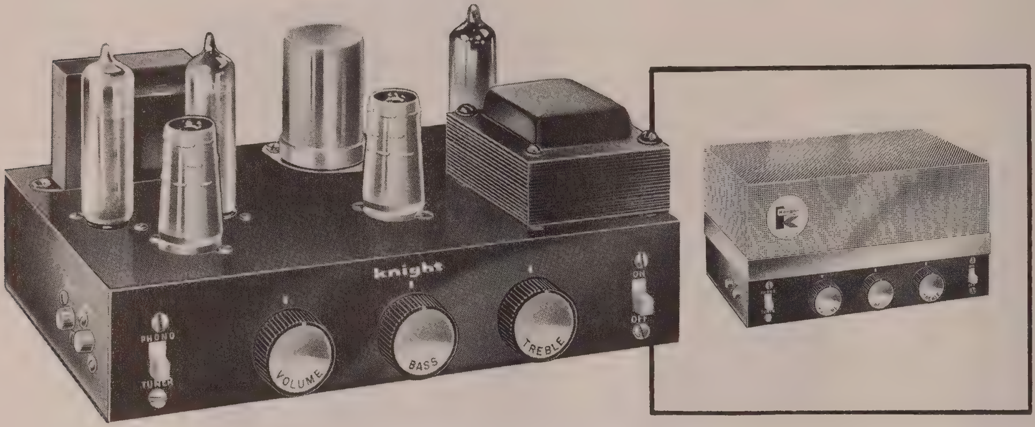
PICTORIAL DIAGRAM
TRANSISTOR CODE PRACTICE OSCILLATOR



TRANSISTOR OSCILLATOR

EQUIVALENT VACUUM TUBE CIRCUIT

SCHEMATIC DIAGRAMS



knight-kit 12-Watt Hi-Fi Amplifier Kit

This 12-watt, high-fidelity amplifier uses one of the finest circuits ever designed for home construction. It's easy to build and it incorporates many deluxe features to bring you superb high fidelity reproduction at far less cost than that of comparable factory-wired units. The addition of a speaker and a record player, plus a radio tuner if desired, will provide a complete high fidelity, home music system.

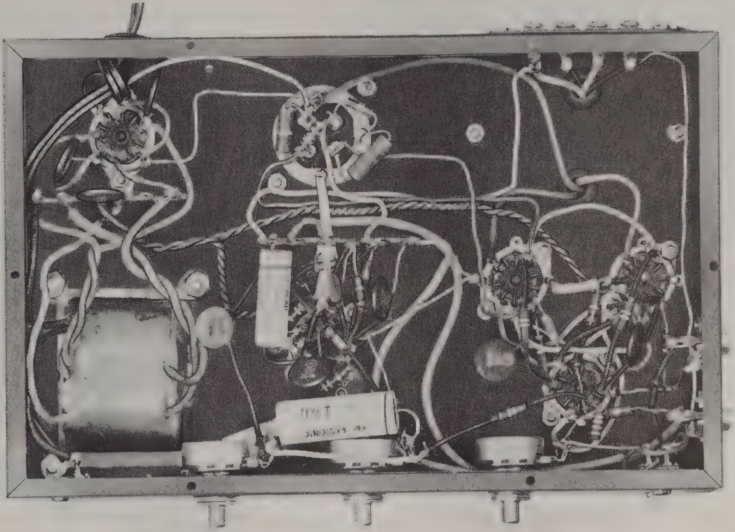
Two inputs are provided, one for a radio tuner and one for a record player. The record player input is equalized for use with magnetic phono cartridges. Output terminals are provided to match any popular speaker impedance (4, 8 and 16 ohms). If your record player has a crystal cartridge, it may be connected to the tuner input.

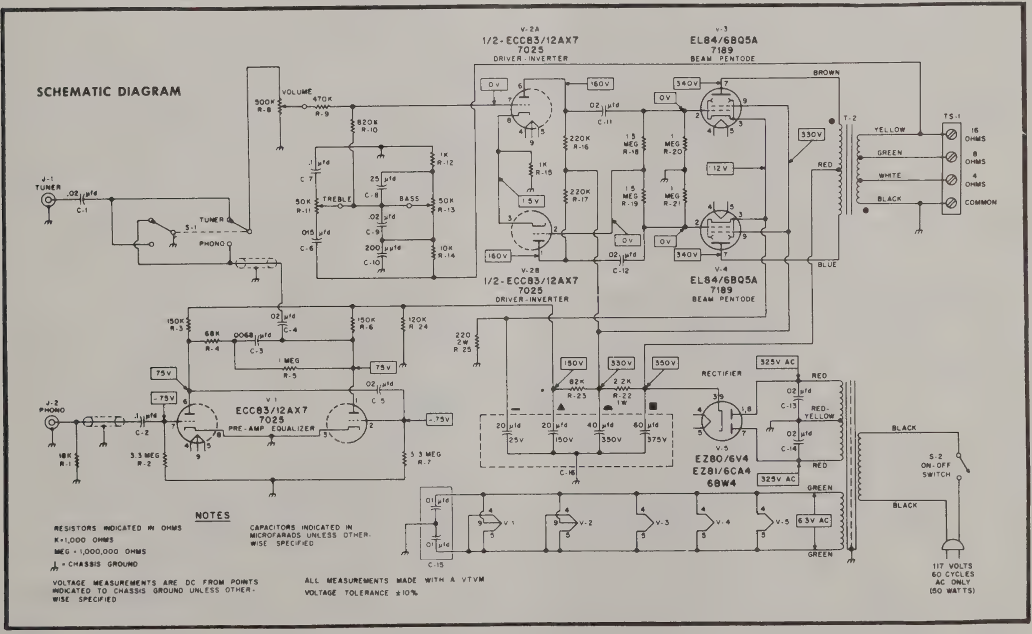
The circuit employs two ECC83/12AX7 dual-triodes, two EL84/6BQ5 beam pentodes and an EZ80/6V4 rectifier. One ECC83/12AX7 provides the preamplification and equalization for magnetic phono cartridges. Its two sections are connected in cascade to obtain the high gain needed. The other ECC83/12AX7 functions as a self-balancing phase-inverter. It splits the signal from the preamplifier into two signals 180° out of phase with each other. These out of phase signals are applied to the grids of the EL84/6BQ5 output tubes for push-pull operation. The outputs of the EL84/6BQ5 power amplifiers are combined in the output transformer and the push-pull operation results in the reduction of distortion by cancelling out harmonics and hum. Feedback voltage is taken from the secondary winding of the output transformer. This voltage serves a dual purpose. First, it is divided through high and low frequency filters to provide bass and treble control; second, it provides a further reduction in distortion.

The Knight-Kit 12-watt amplifier kit is an excellent classroom project for vocational as well as electronic schools. The complete step-by-step instructions supplied make it easy for anyone to assemble—and when completed, this project rewards the builder with a high fidelity amplifier he will be proud to have built.

The complete 12-watt Hi-Fi Amplifier Kit, including punched and drilled chassis, tubes, all parts, wire and solder, step-by-step instructions with large pictorial and schematic diagrams, is listed in the kit section of Allied's catalog.

knight-kit 12-Watt Hi-Fi Amplifier Kit





SCHEMATIC DIAGRAM

NOTES

RESISTORS INDICATED IN OHMS
K=1,000 OHMS
MEG = 1,000,000 OHMS
⏚ = CHASSIS GROUND

VOLTAGE MEASUREMENTS ARE DC FROM POINTS INDICATED TO CHASSIS GROUND UNLESS OTHERWISE SPECIFIED

CAPACITORS INDICATED IN MICROFARADS UNLESS OTHERWISE SPECIFIED

ALL MEASUREMENTS MADE WITH A VTVM
VOLTAGE TOLERANCE ±10%

LISTEN
TALK
knight intercom
ALLIED RADIO · CHICAGO ILLINOIS · MADE IN U.S.A.
LISTEN
TALK
knight
ALLIED RADIO · CHICAGO ILLINOIS · MADE IN U.S.A.

knight-kit 2-way Intercom System Kit

Here's a rewarding project that's easy to assemble. Consisting of a Master unit and a Remote unit, this high-gain two-way intercom kit is a worthwhile system for use in the home, office or store. Special, advanced circuitry is employed for excellent performance and dependable operation.

As in other quality intercom systems, two basic circuits are used in the Master station: an audio amplifier, and a switching arrangement. The audio amplifier uses two tubes, a 12AV6 voltage amplifier and a 50C5 power amplifier. The switching circuit switches the 4″ speaker in the Master station or the 4″ speaker housed in the Remote unit. At any one time, either speaker can be used as a microphone or a conventional speaker. A 35W4 tube serves as a half-wave rectifier for the system.

Provisions for private or non-private operation are incorporated in the intercom. When the "talk-listen" switch on the Remote is in the "listen" position (private), the Master station cannot listen-in. For added convenience, the switch on the Remote station can be left in the "talk" position (non-private) to permit continuous listening-in by the Master. The Master can communicate with the Remote regardless of position of switch on the Remote.

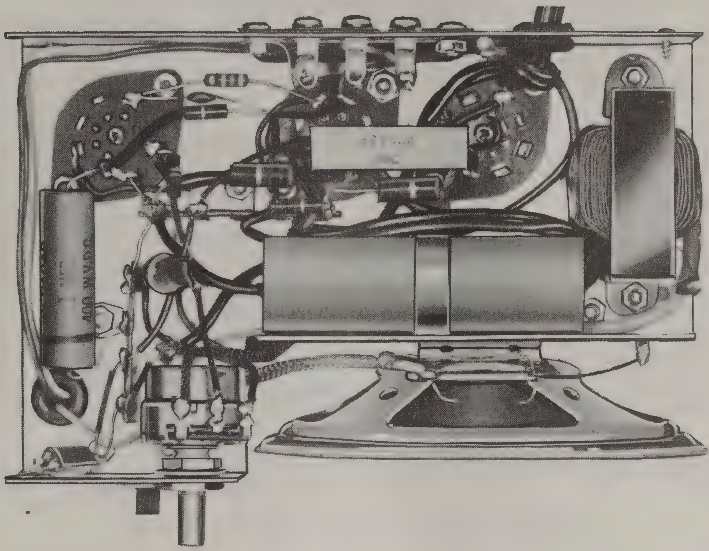
The Master station has a combination volume control and on-off switch. This permits you to regulate the volume of both the Master and the Remote from one central control. In addition to this convenience feature, the Master unit has a pilot light that lets you know—at a glance—when the intercom system is "on". Only the Master station needs to be connected to an AC or DC power source—any 110-125 volt wall outlet will do. The Remote can be located at any desired point and connected to the Master with the wire supplied.

The beginner will gain a great deal of valuable background in electronic circuitry by building this kit. Clearly written instructions and giant-sized picture diagrams will familiarize you with basic types of electronic components.

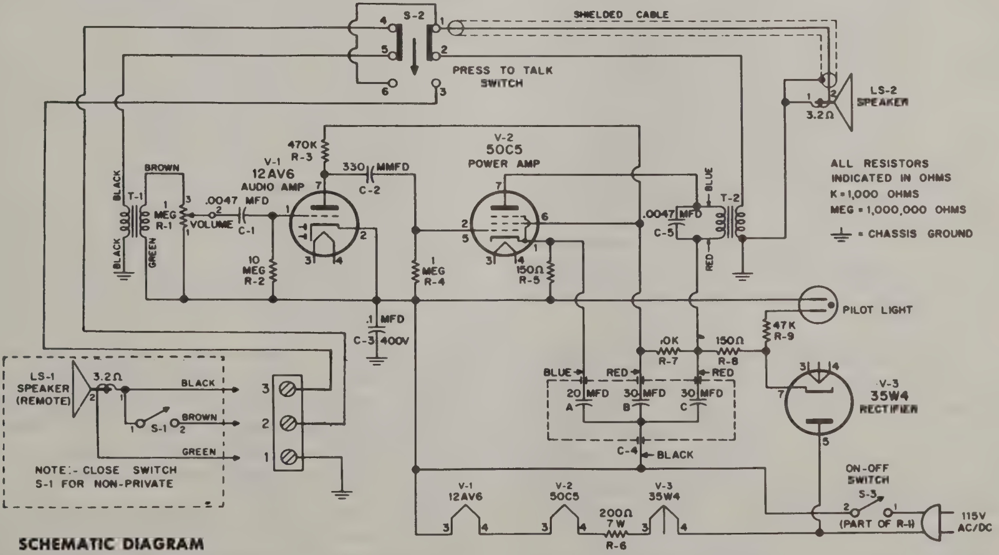
Extra Remote stations are available should you desire to expand the intercom system. The Master unit is designed to accommodate up to three Remotes. In an expanded system, all Remote stations can communicate with each other or the Master.

The kit, complete with two ivory and brown metal cabinets, tubes, pre-punched chassis, speakers, all parts, and wire and solder, and 50-ft. cable, is listed in the kit section of the Allied catalog.

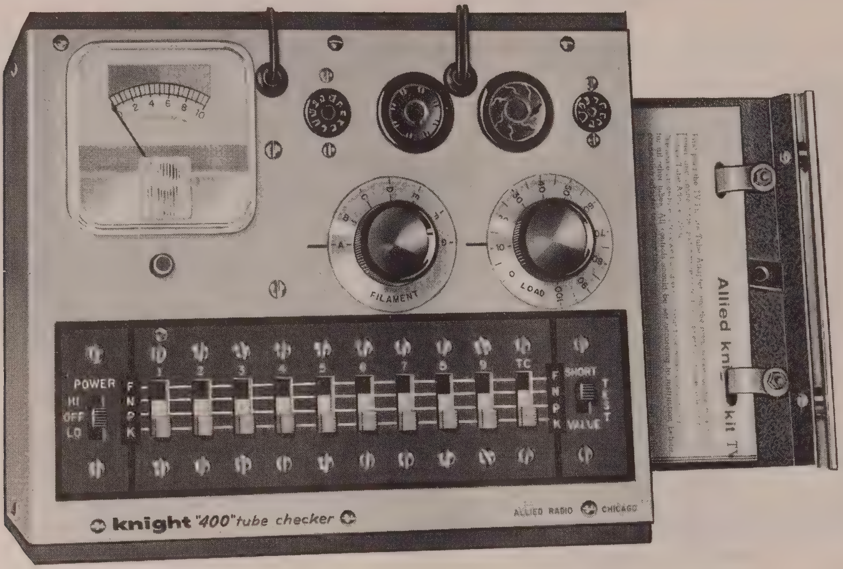
knight-kit 2-way Intercom System Kit



MASTER STATION CHASSIS



SCHEMATIC DIAGRAM



knight-kit "400" Tube Checker Kit

As mentioned on page 31, a tube tester is a helpful instrument for the radio builder. When electronic circuits fail, the tubes are usually the first components checked. Basically, there are three types of tube testers or checkers. The continuity checker which simply tests the tube filaments. The emission checker which measures cathode emission to determine whether a tube is good, bad or weak. This type may or may not check individual elements for shorts. The third type are the transconductance testers which measure conductance relating input (grid) to output (plate) and are calibrated in micromhos (unit of transconductance). Transconductance testers are relatively expensive and are usually found only in laboratories and radio-TV repair shops.

The Knight-Kit "400" tube checker kit, emission-type unit, was designed to provide hobbyists, technicians and students with a fast and reliable tube checker at low cost. Up-to-the-minute circuit design provides facilities for testing over 400 different tube types. These include the most commonly used hi-fi, radio and TV receiving tubes. Sockets are provided for 7-pin and 9-pin miniature, octal and loctal base tubes. Convenient slide switches can be quickly set for making a series of checks for filament continuity, shorted tube elements, and cathode emission. A built-in, slide-out metal drawer contains "Flip-Cards" which give the proper switch settings for making any of these tests.

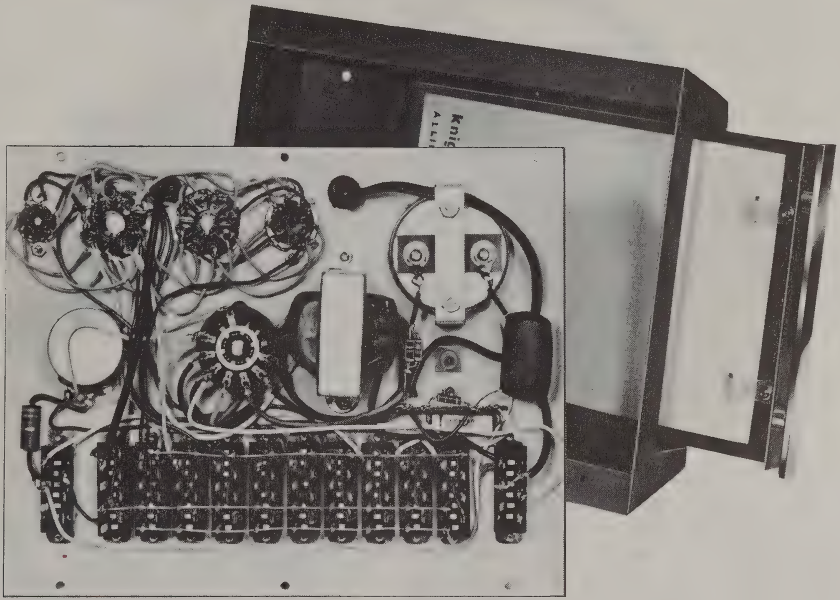
The condition of the tube being checked is indicated by a meter which is calibrated "Replace-Good". In addition, a special scale is provided for checking the condition of diodes and rectifiers.

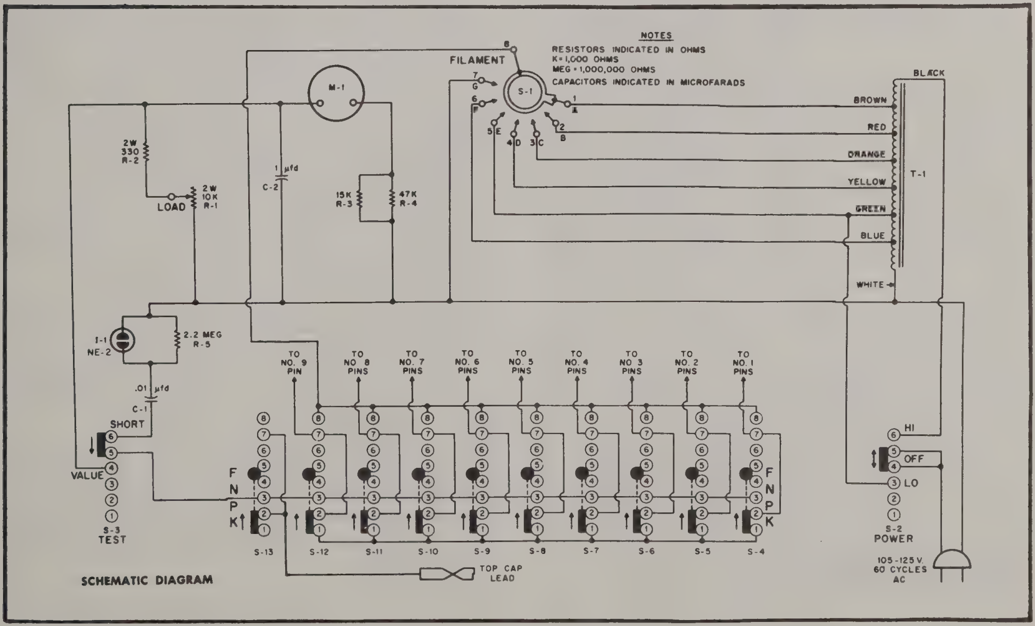
An added feature of the Knight "400" tube checker is its line voltage compensator switch. The switch selects the proper tap on the power transformer to compensate for either high or low voltage line conditions. This feature permits more accurate tube testing and assures proper filament voltages.

In building test equipment from kits, the time-consuming chassis layout and the associated hole cutting and drilling are eliminated. In addition, when the builder selects a Knight-Kit, he gets a tried and proven circuit which is guaranteed to perform in the manner specified.

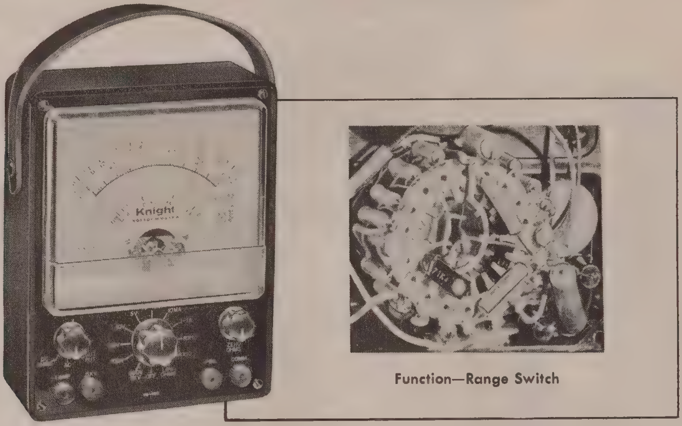
The Knight-Kit "400" tube checker kit, complete with all parts, metal case and instructions is listed in the kit section of the Allied catalog.

knight-kit "400" Tube Checker Kit





SCHEMATIC DIAGRAM



Function—Range Switch

knight-kit 1000 Ohms/Volt VOM Kit

A VOM (volt-ohm-milliammeter) in one of the most basic test instruments, yet it is probably the most useful single piece of equipment for the serviceman, technician, radio amateur and experimenter. Whether you are just getting started in radio and electronics, or if you have already acquired a considerable amount of knowledge and experience, a VOM will undoubtedly be of great value to you.

As its name indicates, a volt-ohm-milliammeter is an instrument used primarily for measuring voltage, resistance and current. You will be able to use a VOM for servicing radios, TV sets, appliances and hundreds of other electrical and electronic devices. Should you go into amateur radio, a VOM will be extremely valuable for servicing your station equipment and for the adjustment of newly built equipment to give peak performance. If your plans include any sort of experimental work, a VOM will give you a clear picture of how well your circuits are operating and also provide you with the necessary data on which to base circuit changes to improve or correct circuit operation.

The Knight-Kit 1000 ohms-per-volt VOM is an excellent example of an instrument of this type. It is easy to use, very accurate and highly versatile — and you can build it yourself at very low cost. It uses a large 4½-inch meter and has 38 ranges to assure easy, accurate readings.

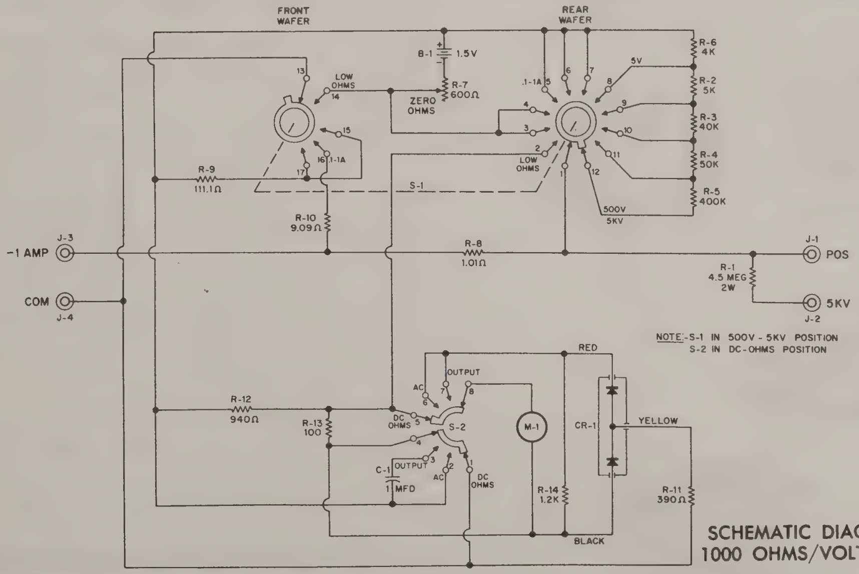
Included in the 38 ranges of the Knight-Kit VOM are seven ranges for measurement of AC, DC and audio output volts, plus 31 ranges for measurement of resistance, AC and DC current, and decibels.

The greater the number of ranges, the easier a meter is to read. For example, the Knight-Kit VOM reads voltage from 0 to 5000 volts. If this entire span of voltage were included in a single 0-to-5000 volt range, it would be impossible to accurately read low and medium voltages, or to detect small differences in voltage, since these voltage indications would occupy only an extremely small percentage of the total meter scale. However, very low, medium and high voltages can easily be read with the Knight-Kit VOM, since the unit provides a choice of seven switch-selected voltage ranges: 0 to 1 volt, 0 to 5 volts, 0 to 10 volts, 0 to 50 volts, 0 to 100 volts, 0 to 500 volts, and 0 to 5000 volts.

In addition to its voltage ranges, the Knight-Kit VOM measures AC and DC current to 1 ampere in three ranges, resistance to 1 megohm in three ranges, and decibels from —20 to +69 in six ranges. Vinyl-covered 1% resistors are used throughout as shunts and multipliers to assure extreme accuracy.

The complete Knight-Kit 1000 ohms-per-volt VOM, with battery, test leads, solder, pre-cut wire, step-by-step assembly instructions, and detailed operating instructions, is listed in the kit section of the Allied catalog.

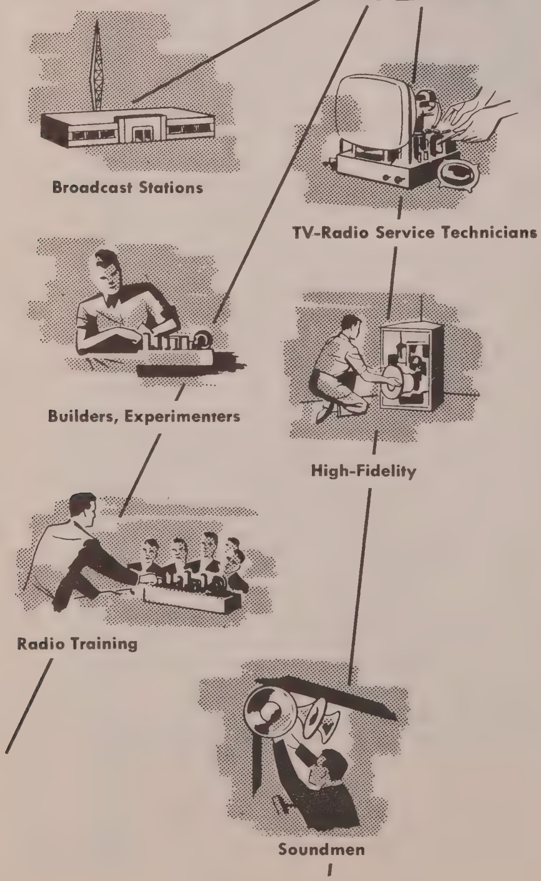
knight-kit 1000 Ohms/Volt VOM Kit



SCHEMATIC DIAGRAM
1000 OHMS/VOLT VOM

ALLIED

complete centralized service for everything in electronic equipment



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From Radio's earliest days, ALLIED has offered its specialized experience and unflagging personal interest to many thousands of beginners and veterans in the field.

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ALLIED RADIO CORPORATION

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NOTES

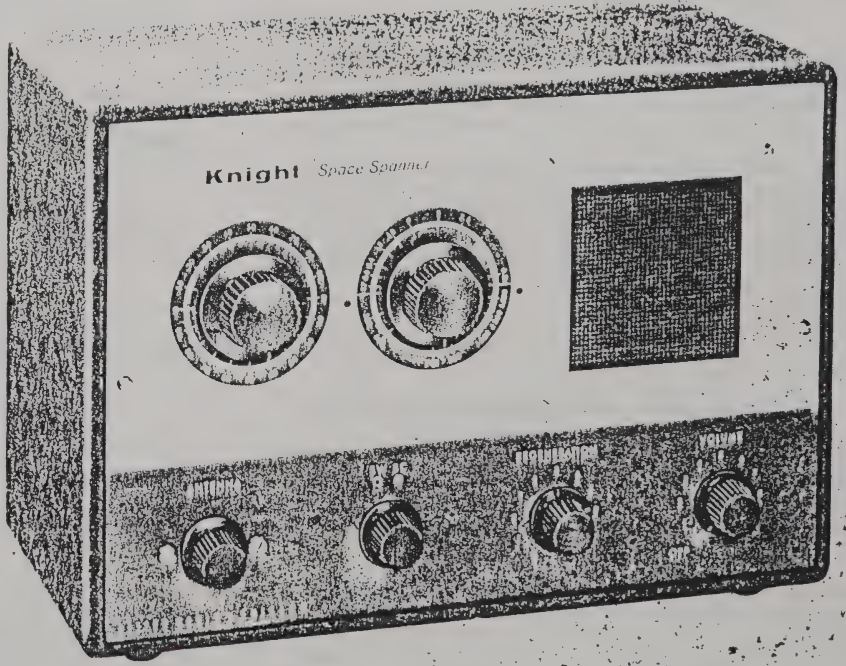
NOTES

knight-kits

Allied knight®-kit

SPACE SPANNER

83 Y 259



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THE KNIGHT SPACE SPANNER

Your Space Spanner is a highly efficient regenerative radio receiver. It covers the Broadcast Band from 540 to 1700 kilocycles, and the Short-Wave Band from 6.5 to 17 megacycles. This Short-Wave Band coverage includes the 40 and 20 meter Amateur Bands, the 49, 41, 40, 31, 25, 20 and 19 meter International Bands, and Station WWV at 10 and 15 megacycles. Either the built-in speaker or a headset may be used to listen to the Space Spanner.

CHECKING YOUR KIT

Before starting to build your Space Spanner receiver, check each part against the Parts List on page 23. If you are unable to identify some of the parts by sight, locate them on the pictorial diagrams. Capacitor and resistor values, if not printed on the part, may be found with the aid of the color code chart.

Keep the different sizes of screws and nuts separate for convenience in building. Four sizes are used: Two self-tapping, seven very short screws, 18 medium length, and 4 long thin screws.

CONSTRUCTION HINTS

The only tools and materials required for building your Space Spanner are: Long-nose pliers, diagonal cutters, screwdriver, and a soldering iron. A good set of tools and supplies is listed at the end of the Parts List.

Study the pictorial diagrams and note how the parts are mounted. These pictorial diagrams show the actual location of all parts and wires. The schematic diagram shows how the parts are connected electrically and is helpful in understanding how the circuits work.

The step-by-step instructions are the best and fastest way of assembling this unit. May we suggest that you check off each step after you have completed it. Some builders also put a pencil mark on the wiring views along the wires and parts that they have just installed. Both of these methods are good and will assure speedy and correct wiring.

MOUNTING THE PARTS ON THE CHASSIS

Begin building your Space Spanner by mounting the parts.

SEE FIGURE 1

☑ Turn the chassis upside-down so the bent edges are pointing up. The edge with the printing on the outside is the REAR of the chassis.

☐ Insert a large grommet into each of the three ⅜″ holes in the chassis by pushing them into the holes until the grooves around the outer edge of each grommet "locks" into the hole in the chassis. Figure 1 shows the grommets mounted in their proper holes.

☑ Three tube sockets are supplied with this kit. Two of them have seven pins and the third has nine pins. One of the 7-pin sockets (labeled V-2 in Figure 1) is to be mounted over the large hole near the right rear edge of the chassis. Mount the 7-pin socket using two medium length screws and two nuts that fit the screws. The screws must be inserted from the outside of the chassis, and the socket must be **mounted inside the chassis.** Notice that there is a wide open space between two of the pins on the socket. This wide space is known as the "keyway", and must be positioned as shown in the figure.

☑ Mount the other 7-pin socket (V-3 in Figure 1) over the large hole near the socket just mounted with two medium length screws and nuts. Notice that a 2-terminal strip (TS-2 in Figure 1) is mounted on top of the socket under the front socket mounting nut. Be sure to position the socket keyway as shown.

☑ Mount the 9-pin socket (V-1) over the largest hole in the chassis. A solder lug (a short, flat piece of metal with a large hole in one end and a smaller hole in the other) must be mounted **between the socket and the chassis.** The keyway on the socket must be toward the left side of the chassis as shown. Use two medium length screws and nuts to mount the socket and the solder lug.

☑ Next, mount the filter choke (L-4) on the OUTSIDE of the chassis using two medium length screws and nuts. The position of the filter choke is indicated by a broken (dashed) line in Figure 1. If you do not know what the filter choke looks like, see Figure 2 on page 5. After L-4 is mounted, push its two wires through the grommet between V-2 and V-3 so they can be connected inside the chassis.

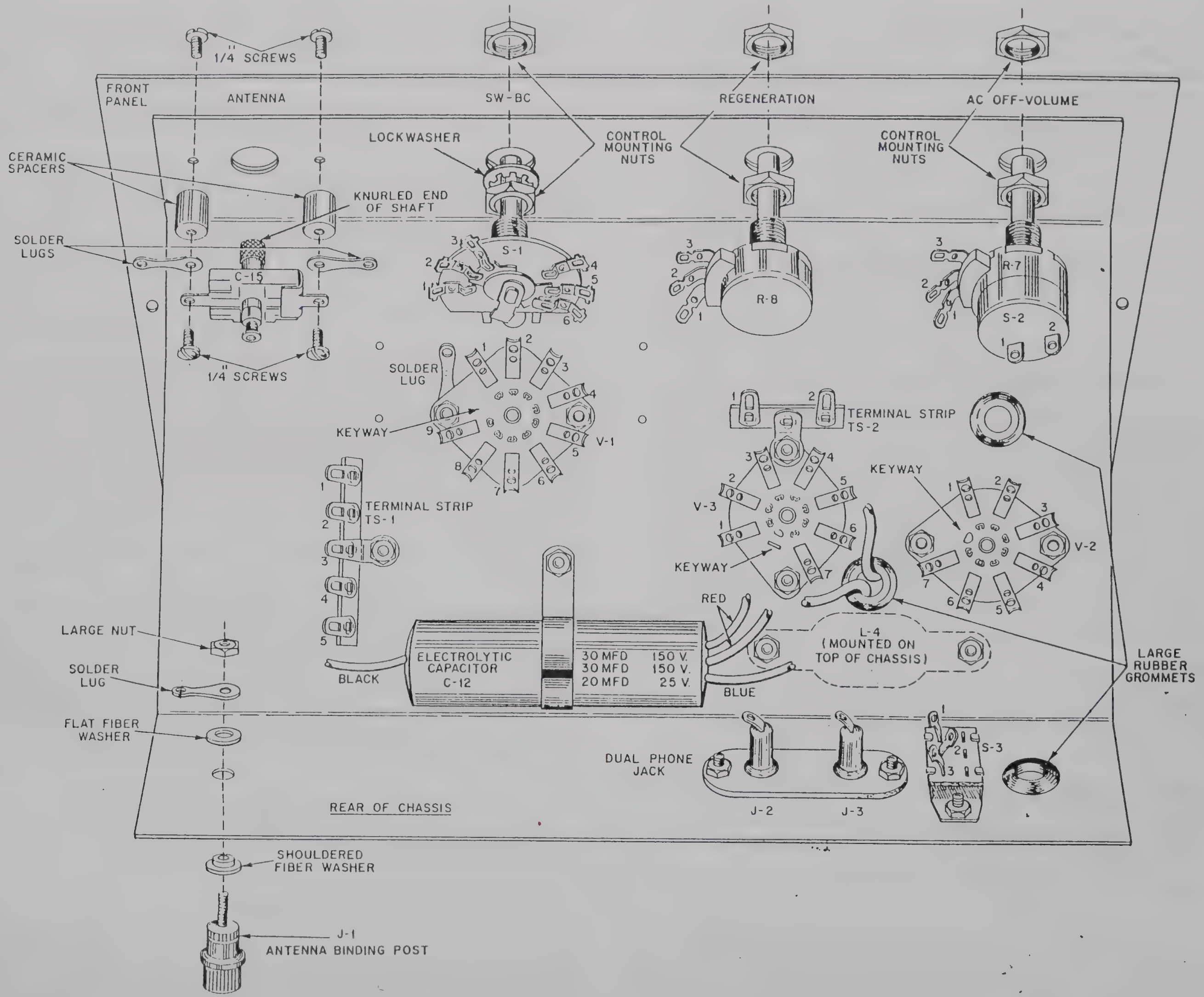


FIGURE 1. HOW TO MOUNT THE PARTS ON THE CHASSIS

☑ Mount the dual phone jack (J-2 and J-3) **inside the rear of the chassis** with two medium length screws and nuts in the position shown in Figure 1. This jack may appear slightly different, but it is electrically identical.

☑ Mount slide switch (S-3) inside the rear of the chassis as shown in Figure 1. Use two medium length screws and nuts to mount S-3.

☐ C-12 is a large electrolytic capacitor with a black lead on one end, and two red leads and a blue lead on the other. Bend the mounting strap, and mount C-12 with one medium length screw through the chassis and the end of the mounting strap so that the black lead is toward the left side of the chassis, as shown in Figure 1. Use a nut that fits the screw to secure C-12 to the chassis.

☑ Mount the 5-terminal strip (TS-1) in the position shown with a medium length screw and nut.

☐ J-1, the Antenna binding post, must be mounted with a shouldered fiber washer, a flat fiber washer, a solder lug, and a large nut. Remove the nut from the binding post, place the shouldered washer on the threaded portion of the binding post, and insert it through the hole marked ANTENNA so that the shouldered part of the shouldered washer fits in the hole. From the inside of the chassis place the flat fiber washer on the binding post. Now, place a solder lug on J-1. Finally, securely tighten a large nut onto the threaded portion.

NOTE: Be careful not to scratch or mar the finish on the front panel when you mount it.

☑ When you mount the front panel to the chassis, notice that the four holes in the panel and the chassis match. Tighten a very large nut over the threaded bushing of the volume control, marked R-7 and S-2 in Figure 1. From INSIDE the chassis insert the shaft through the extreme right hand hole in both the chassis AND panel. From OUTSIDE the front panel loosely tighten a very large nut over the threaded bushing to secure the panel to the chassis and the volume control to both. The terminals must be positioned as shown in Figure 1.

☑ In the same manner, mount the Regeneration control (marked R-8 in Figure 1) in the hole marked REGENERATION on the front panel. The three terminals on the side of this control also must point toward the center of the front of the chassis.

☐ Mount the Short Wave-Broadcast switch (marked S-1 in Figure 1) in the hole marked SW-BC on the front panel. This switch is mounted the same way as the volume and regeneration controls, except that an internal-tooth lockwasher must be placed on the shaft before it is inserted into its mounting hole. The flat side of this switch must be towards the bend in the front of the chassis, as shown in Figure 1.

☑ Mount the antenna trimmer capacitor (C-15 in Figure 1) next with 4 medium length screws, 2 ceramic spacers, and 2 solder lugs. First, insert two screws through the small holes on either side of the hole marked ANTENNA on the front panel so that the threaded part of each extends through to the inside of the chassis. Now, screw one of the ceramic spacers onto each screw. **BE VERY CAREFUL. THE SPACERS MAY CRACK IF THE SCREWS ARE TIGHTENED TOO SECURELY.** A solder lug must be placed between the terminals of C-15 and the other end of the spacers before the other screws are inserted. Secure C-15 to the other end, with the other two screws, so that the knurled end of the shaft extends through the hole marked ANTENNA.

☑ Securely tighten the outside nuts on the SW-BC switch, the REGENERATION control, and the VOLUME control.

SEE FIGURE 2.

☑ Turn the chassis over and position it as shown in Figure 2.

☐ When you mount the speaker, **BE VERY CAREFUL NOT TO PUNCTURE THE PAPER CONE.** Insert a small rubber grommet into the ¼″ holes in each corner of the speaker. Mount the grille and the speaker to the front panel using one of the long thin screws through each small hole at the corner of the front-panel cutout. From INSIDE the panel place the perforated grille over the cutout so the screws come through the large holes in the grille. Now, mount the speaker so the screws come through the grommets in the corners of the speaker. Be sure to position the speaker so T-1 (the output transformer is toward the chassis. Tighten a matching nut onto each of the screws. Push the red and blue wires through the large grommet below the speaker so they can be connected later inside the chassis.

NOTE: The MAIN TUNING capacitor, C-2, and the BANDSPREAD capacitor, C-3, are both variable capacitors. Their appearance is similar, except C-2 has many plates and C-3 has only five. C-2 has two terminals on only one side, and C-3 has two terminals on each side.

☑ Mount the MAIN TUNING capacitor, C-2, behind the front panel by inserting the shaft of C-2 through the large hole (marked MAIN tuning) and tightening one of the very short screws into each of the three threaded holes in C-2 from OUTSIDE the front panel.

☑ Mount a solder lug on the rear of C-2 with another very short screw as shown in Figure 2.

☑ Mount the BANDSPREAD capacitor, C-3, in the same way.

You have finished mounting most of the parts on the chassis and front panel. The two coils that are wound on the fiber tubes will be mounted later. DO NOT MAKE ANY SOLDER CONNECTIONS UNTIL YOU HAVE STUDIED THE SOLDER INSTRUCTIONS.

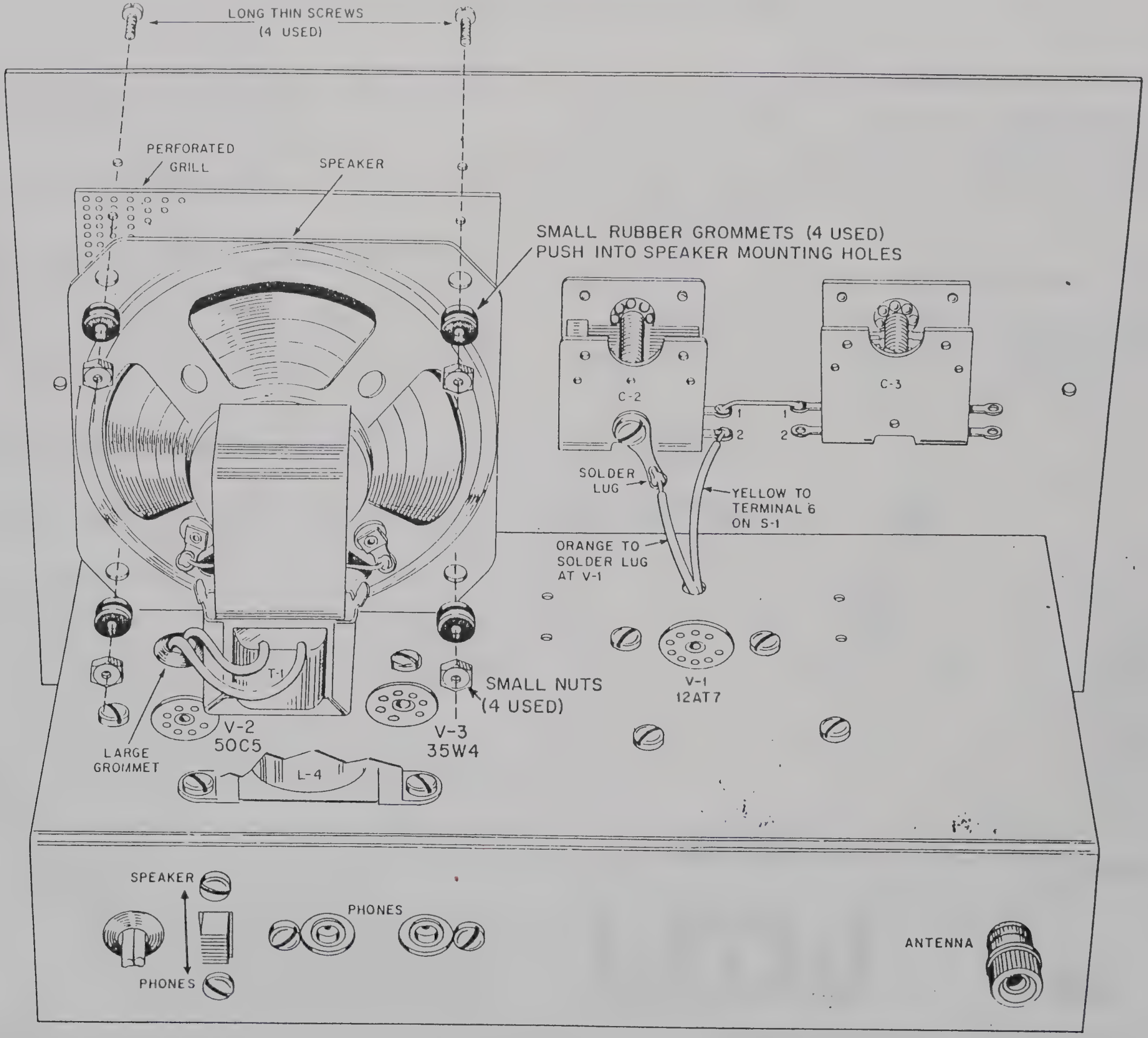


FIGURE 2. HOW TO MOUNT THE PARTS ON THE FRONT PANEL

THIS KIT MUST BE *PROPERLY* SOLDERED!

WITHOUT GOOD SOLDERING, AN ELECTRONIC UNIT WILL NOT WORK . . . just as a suit of clothing will fall apart if the stitches are loose . . . no matter how excellent the material.

USE ENOUGH HEAT

This is the main idea of good soldering. The purpose of soldering is to join metal parts, making an UNBROKEN metal path over which electricity can travel. To do this you must apply enough heat to the metal surfaces to make the solder spread freely on them, until the contour (shape) of the connection shows under the solder. If the solder barely melts and forms a rounded ball, *you are not using enough heat*. If you do not use enough heat, there may be no electrical connection, although it appears soldered.

HERE'S HOW TO DO IT . . .

1. Join bare metal to bare metal. Insulation must be removed.
2. Coat the tip of a hot iron with solder.
3. FIRMLY PRESS THE FLAT SIDE OF THE TIP OF A HOT IRON FLAT against the parts to be soldered together. Keep it there while you apply the solder BETWEEN THE IRON TIP AND THE METAL TO BE SOLDERED. Use only enough solder for it to flow over ALL the surfaces of the connection. Remove the iron.
4. DO NOT MOVE PARTS UNTIL THE SOLDER HARDENS. If you accidentally move the wires as the solder is hardening, apply your iron and reheat.

Compare your soldering with the pictures on this page. You have a good connection if your solder has flowed over all surfaces to be connected, following the shape of the surfaces. It should appear smooth and bright.

YOU HAVE NOT USED ENOUGH HEAT: If your connection is rough and flaky-looking, or if the solder has formed a round ball instead of spreading.

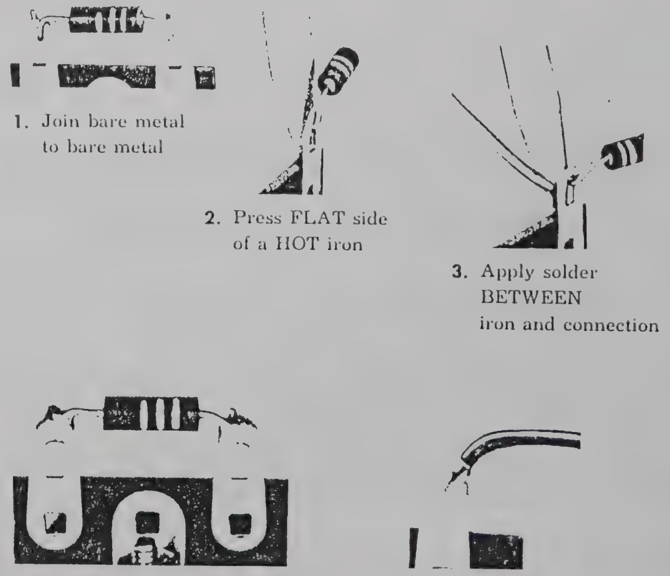
The difference between good soldering (enough heat) and poor soldering (not enough heat,) is just a few extra seconds with a hot iron FIRMLY applied. Remember, larger metal surfaces take a longer time to heat.

USE A 100-WATT IRON

A 100-watt soldering iron with a clean, chisel-shaped tip will supply the right amount of heat when used correctly. Notice how the iron is held in the picture. Heat the iron for 10 minutes before you start soldering. Keep the tip brightly coated with solder. When necessary, wipe the hot tip clean with a cloth. (If you use a soldering gun, be sure the tip reaches full heat before you solder.)

USE ONLY ROSIN CORE SOLDER

We supply the right kind of solder *(rosin core solder)*. Do not use any other kind of solder! USE OF ACID CORE SOLDER, PASTE, OR IRONS CLEANED ON A SAL AMMONIAC BLOCK WILL RUIN ANY ELECTRONIC UNIT AND WILL VOID THE GUARANTEE.



1. Join bare metal to bare metal

2. Press FLAT side of a HOT iron

3. Apply solder BETWEEN iron and connection

Compare your soldering with these pictures.

FIGURE 3. THE ONE-TWO-THREE OF GOOD SOLDERING.

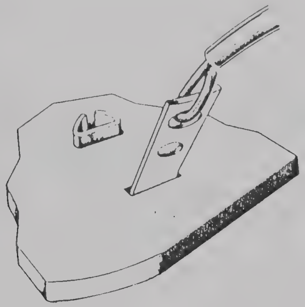


FIGURE 4. HOW TO CONNECT A WIRE TO TERMINAL

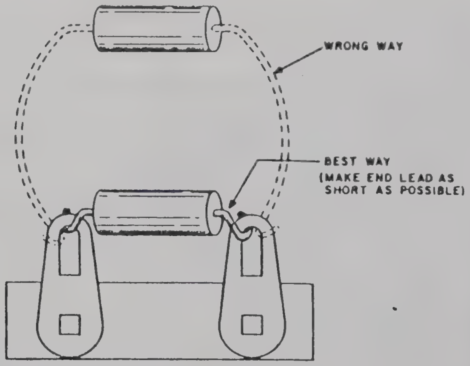


FIGURE 5. THE BEST WAY TO MOUNT A COMPONENT

WIRING NOTES

The insulated wire furnished with this kit is cut to length and the ends are stripped. Each different colored wire is a certain length, so be sure to use the color specified in each of the wiring steps.

Whenever a piece of bare wire is to be used, the exact length is given in the wiring step. Measure the wire before cutting it.

The proper way to connect a wire to a terminal is shown in Figure 4. To connect the wire, first bend a hook in the end with your long-nose pliers. Then pass the end of the hook through the hole in the terminal. Last, squeeze the wire onto the terminal so that it is solidly mounted. **All connections must be mechanically strong BEFORE solder is applied. Solder must NOT be used to supply mechanical strength—its ONLY purpose is to assure a good ELECTRICAL connection.**

The proper way to connect a component (resistor, capacitor, choke, etc.) is illustrated in Figure 5. Pull the end leads of the part being mounted through the holes in the mounting terminals so that the part is tightly mounted. Cut off any excess leads.

The soft tubing supplied is called "spaghetti". Spaghetti is used to cover the bare end leads on some of the parts. Whenever it is necessary to use some of the spaghetti, the exact length is given in the step.

Do your best to position all of the parts and wires as shown in the wiring diagrams. Place all long wires as close to the chassis as possible.

WIRING THE REAR OF THE FRONT PANEL

SEE FIGURE 2.

☑ Cut off a 1¾″ piece of bare wire. Solder one end of the wire to terminal 1 on C-3. Solder the other end to terminal 1 on C-2.

NOTE: IN THIS MANUAL, WHEN THE WORD "SOLDER" APPEARS, IT MEANS TO CONNECT THE WIRE OR LEAD TO THE TERMINAL, AND THEN TO SOLDER IT AND ALL OTHER WIRES CONNECTED TO THE TERMINAL TOGETHER. WHEN THE WORDS "CONNECT, BUT DO NOT SOLDER" APPEAR, SOLDER IS NOT TO BE USED BECAUSE THERE ARE OTHER WIRES TO BE CONNECTED TO THE TERMINAL. ONLY SOLDER WHEN THE WORD "SOLDER" APPEARS.

☑ Solder one end of a yellow wire to terminal 2 of C-2. Insert the other end through the hole below C-2.

☑ Solder one end of an orange wire to the solder lug on the rear of C-2. Insert the other end through the hole below C-2.

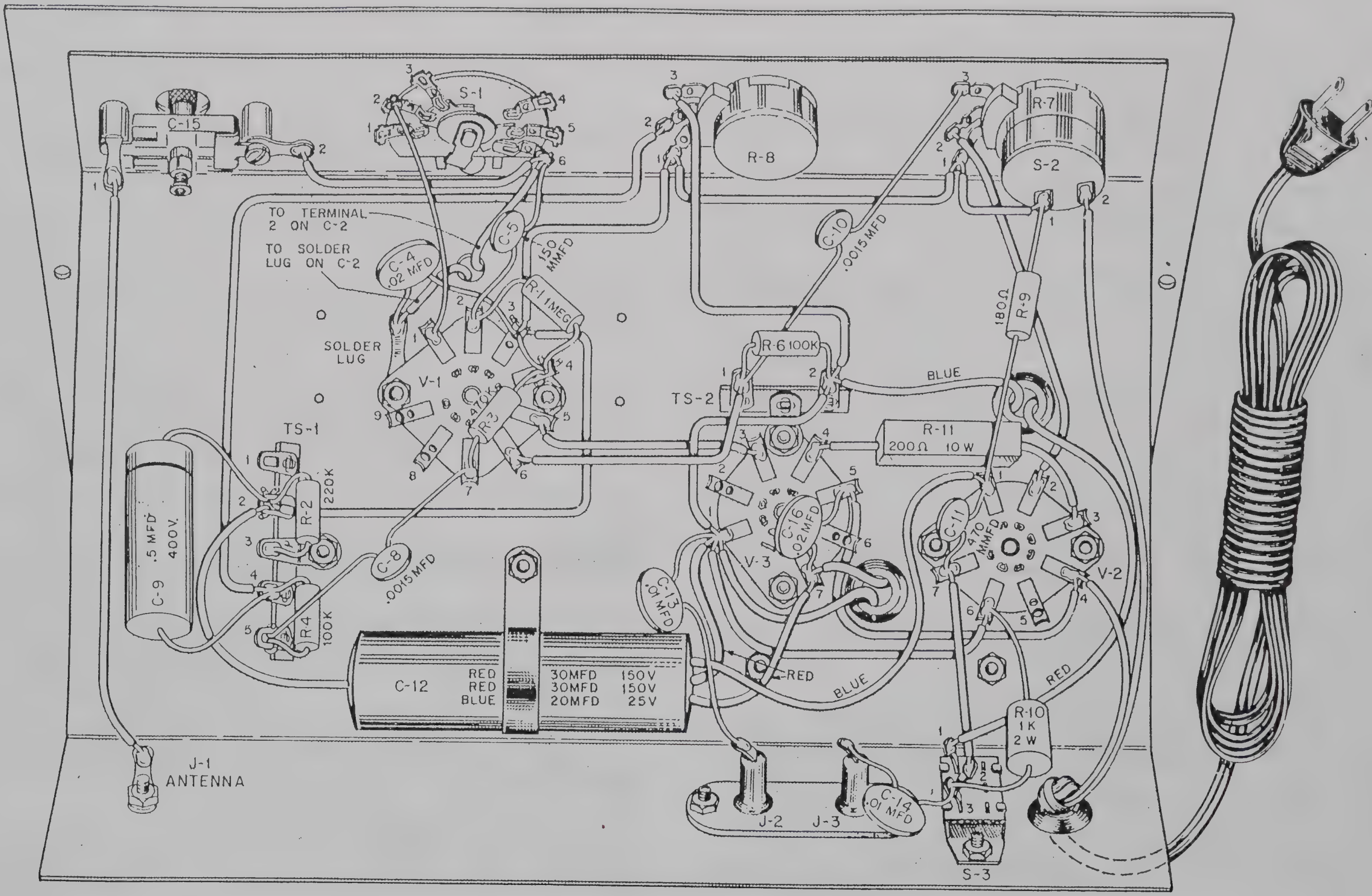


FIGURE 6. FIRST CHASSIS WIRING VIEW

WIRING THE CHASSIS

TURN THE CHASSIS UPSIDE DOWN AND REFER TO FIGURE 6.

☑ Connect, but do not solder, one end of a green wire to pin 4 of V-2. Connect, but do not solder, the other end to pin 5 of V-3. **NOTE:** The terminals on the tube sockets are called pins.

☑ Connect, but do not solder, one end of a yellow wire to pin 6 of V-2. Connect, but do not solder, the other end to pin 1 of V-3.

☑ Connect, but do not solder, one end of a red wire to pin 7 of V-2. Solder the other end to terminal 2 of S-3.

☑ Solder one end of an orange wire to terminal 2 of R-7. Solder the other end to pin 2 of V-2.

☑ Place 1½″ of spaghetti on one of the end leads of R-11, the large resistor with 200 ohms, 10 watts printed on its body. Solder this lead to pin 4 of V-3. Place ¾″ of spaghetti on the other end lead. Solder this lead to pin 3 of V-2.

☑ Solder one end of an orange wire to pin 5 of V-1. Solder the other end to pin 3 of V-3.

☐ Connect, but do not solder, one end of an orange wire to terminal 2 of TS-2. Connect, but do not solder, the other end to pin 1 of V-3.

☐ There are red and blue wires coming out of the grommet in front of V-2. Cut just enough off the blue wire so that it can be connected to terminal 2 of TS-2. Remove ¼″ of insulation from the end of the blue wire. Connect, but do not solder, it to terminal 2 of TS-2.

☐ Cut just enough off the red wire so that it can be connected to terminal 1 of S-3. Remove ¼″ of insulation from the end of the red wire. Solder it to terminal 1 of S-3.

☐ Cut just enough off the end of the blue wire on C-12, the large electrolytic capacitor, so that it can be connected to pin 1 of V-2. Remove ¼″ of insulation from the end of the blue wire. Connect, but do not solder, it to pin 1 of V-2.

☑ Cut just enough off the end of either of the red wires on C-12 so that it can be connected to pin 7 of V-3. Remove ¼″ of insulation from the end of this wire. Connect, but do not solder, it to pin 7 of V-3.

☑ Cut just enough off the other red wire on C-12 so that it can be connected to pin 1 of V-3. Remove ¼″ of the insulation from the end of this wire. Connect, but do not solder, it to pin 1 of V-3.

☑ Cut just enough off the end of either of the black wires coming through the grommet between V-2 and V-3 so that it can be connected to pin 7 of V-3. Remove ¼″ of insulation from the end of this wire. Connect, but do not solder, it to pin 7 of V-3.

☑ Cut just enough off the end of the other wire in this grommet so that it can be connected to pin 1 of V-3. Remove ¼″ of insulation from the end of this wire. Connect, but do not solder, it to pin 1 of V-3.

☑ Connect, but do not solder, the yellow wire in the hole in front of V-1 that comes from terminal 2 of C-2 to terminal 6 of S-1.

☑ Connect, but do not solder, the orange wire in the same hole to the solder lug under the left side of V-1.

☑ Cut just enough off the black wire on C-12 so that it can be connected to terminal 2 of TS-1. Remove ¼″ of insulation off the end of this wire. Connect, but do not solder, it to terminal 2 of TS-1.

☐ The line cord is the long wire with a plug on one end. From outside the chassis, insert the end of the line cord with the bare wire ends through the grommet in the rear of the chassis. Inside the chassis, tie a knot in the cord 4″ from the bare wire ends. Grasping one of the bare ends in each hand, pull them apart so the cord splits all the way back to the knot. Solder either of the bare ends to terminal 2 of S-2.

☐ Cut just enough off the other wire of the line cord so that it can be connected to pin 4 of V-2. Strip ¼″ of insulation off the end of this wire. Solder it to pin 4 of V-2.

CAUTION: NEVER TOUCH ANY PART OF THE WIRING WHILE THIS RECEIVER IS PLUGGED INTO A POWER OUTLET. NEVER USE OR TEST THE SPACE SPANNER ON OR NEAR A GROUNDED METAL BENCH, RADIATOR, SINK, OR OTHER GROUNDED METAL OBJECT.

☑ Solder one end of R-10, the large 1K ohm resistor with brown, black, and red colored bands on its body, to pin 6 of V-2. Connect, but do not solder, the other end to terminal 3 of S-3. **PLEASE NOTE:** Some of the resistors in this kit may have a fourth color band, either silver or gold. Pay no attention to this band.

NOTE: Disc capacitors may be marked in more than one way. An example: An .01 MFD may also be marked 10K or 10,000; an .0015 may be marked 1500 or 1.5K; a 150 MMFD may be .00015.

☑ Solder one end of C-14, a disc-shaped capacitor with .01 MFD printed on its body, to J-3. Solder the other end to terminal 3 of S-3.

☑ Solder one end of C-13, another .01 MFD disc capacitor, to J-2. Solder the other end to pin 1 of V-3.

☑ Solder one end of C-16, a .02 MFD disc capacitor, to pin 7 of V-3. Solder the other end to pin 5 of V-3.

☑ Solder one end of C-11, a 470 MMFD disc capacitor, to pin 7 of V-2. Connect, but do not solder, the other end to pin 1 of V-2.

☑ Solder one end of R-9, a 180 ohm resistor (brown, gray, brown), to pin 1 of V-2. Connect, but do not solder, the other end to terminal 1 of S-2.

☑ Solder one end of a red wire to terminal 1 of S-2. Connect, but do not solder, the other end to terminal 1 of R-7.

☑ Solder one end of a yellow wire to terminal 1 of R-7. Connect, but do not solder, the other end of terminal 1 of R-8.

☑ Solder one end of C-10, a .0015 MFD disc capacitor, to terminal 3 of R-7. Connect, but do not solder, the other end to terminal 1 of TS-2.

☑ Connect, but do not solder, one end of R-6, a 100K ohm resistor (brown, black, yellow), to terminal 1 of TS-2. Connect, but do not solder, the other end to terminal 2 of TS-2.

☑ Solder one end of an orange wire to terminal 1 of TS-2. Solder the other end to pin 6 of V-1.

☑ Solder one end of a yellow wire to terminal 1 of R-8. Connect, but do not solder, the other end to pin 3 of V-1.

☑ Solder one end of a gray wire to terminal 2 of R-8. Connect, but do not solder, the other end to terminal 4 of TS-1.

☐ Solder one end of a yellow wire to terminal 2 of TS-2. Solder the other end to terminal 3 of R-8.

☑ Solder one end of C-4, a .02 MFD disc capacitor, to the solder lug under the left side of V-1. Connect, but do not solder, the other end to pin 3 of V-1.

☐ Pass one end of a green wire through pin 3 of V-1. Connect it to pin 4 of V-1. Do not solder either terminal. Connect, but do not solder the other end to terminal 2 of TS-1.

☑ Connect, but do not solder, one end of an orange wire to terminal 6 of S-1. Solder the other end to the right solder lug on C-15 (labeled 2 in Figure 6).

☑ Solder one end of C-5, a 150 MMFD disc capacitor, to terminal 6 of S-1. Connect, but do not solder, the other end to pin 2 of V-1.

☑ Solder one end of R-1, a 1 megohm resistor (brown, black, green), to pin 2 of V-1. Connect, but do not solder, the other end to pin 4 of V-1.

☑ Solder one end of a 2″ bare wire to terminal 2 of S-1. Solder the other end to pin 1 of V-1.

☑ Connect, but do not solder, one end of R-3, a 470K ohm resistor (yellow, violet, yellow), to pin 4 of V-1. Connect, but do not solder, the other end to pin 7 of V-1.

☑ Connect, but do not solder, one end of R-2, a 220K ohm resistor (red, red, yellow), to terminal 2 of TS-1. Solder the other end to terminal 3 of TS-1.

☐ Connect, but do not solder, one end of R-4, a 100K ohm resistor (brown, black, yellow), to terminal 4 of TS-1. Connect, but do not solder, the other end to terminal 5 of TS-1.

☑ Solder one end of C-8, a .0015 MFD disc capacitor, to pin 7 of V-1. Connect, but do not solder, the other end to terminal 5 of TS-1.

☐ Connect, but do not solder, the black banded end of C-9, a .5 MFD, 400 V paper capacitor, to terminal 2 of TS-1. Solder the other end to terminal 4 of TS-1.

☐ Bend the left solder lug (labeled 1 in Figure 6) as shown. Solder one end of a yellow wire to terminal 1 of C-15 (the left solder lug). Solder the other end to the solder lug on the antenna binding post (J-1).

REFER TO FIGURE 7 FOR THE FOLLOWING STEPS:
DO NOT MIX L-1 and L-2

☐ Mount L-1, the coil with few turns of heavy wire, in the position shown in Figure 7 by inserting its threaded mounting studs through the coil mounting holes in the chassis. The terminals on one side of the coil must face V-1. Secure L-1 with one nut on each stud on the outside of the chassis.

☐ Mount L-2, the coil with many turns of fine wire, on the other side of V-1 with two nuts. Its terminals must also face V-1.

☐ Solder one end of an orange wire to terminal 1 of L-2. Connect, but do not solder, the other end to pin 3 of V-1.

☐ Solder one end of R-5, a 270 ohm resistor (red, violet, brown), to pin 3 of V-1. Solder the other end to pin 8 of V-1.

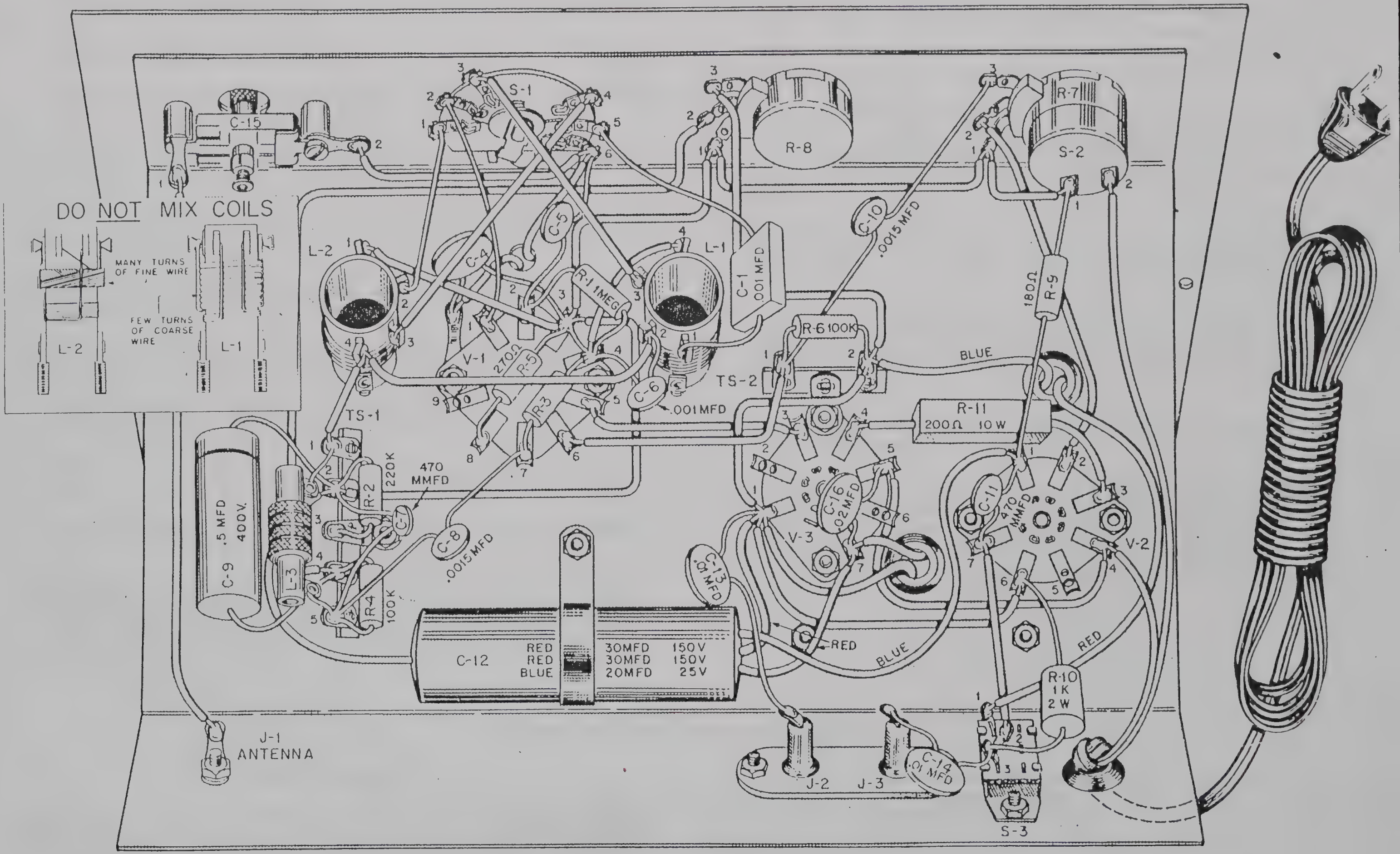


FIGURE 7. SECOND CHASSIS WIRING VIEW

☐ Solder one end of a 1½″ bare wire to terminal 2 of L-2. Solder the other end to terminal 1 of S-1.

☐ Solder one end of an orange wire to terminal 3 of L-2. Solder the other end to terminal 4 of S-1.

☐ Connect, but do not solder, one end of a red wire to pin 4 of V-1. Solder the other end to terminal 4 of L-1.

☐ Solder one end of a red wire to terminal 3 of S-1. Solder the other end to terminal 3 of L-1.

☐ Solder one end of C-1, the .001 MFD (1000 MMFD) rectangular mica capacitor, to terminal 5 of S-1. Solder the other end to terminal 1 of L-1.

☐ Connect, but do not solder, one end of C-6, a .001 MFD disc capacitor, to terminal 2 of L-1. Solder the other end to pin 4 of V-1.

☐ Solder one end of an orange wire to terminal 2 of L-1. Connect, but do not solder, the other end to terminal 4 of L-2.

☐ Solder one end of a red wire to terminal 4 of L-2. Connect, but do not solder, the other end to terminal 1 of TS-1.

☐ Solder one end of C-7, a 470 MMFD disc capacitor, to terminal 2 of TS-1. Connect, but do not solder, the other end to terminal 5 of TS-1.

☐ Solder one end of L-3, the RF choke, to terminal 1 of TS-1. Solder the other end to terminal 5 of TS-1.

☐ You have finished wiring your KNIGHT Space Spanner. All connections should be soldered. Check each of them. If any are not soldered, check to see if you have skipped a step. Remember, a few minutes spent in careful checking now may save hours of troubleshooting later.

☐ Rotate the **BANDSPREAD** control shaft until the plates of C-3 are closed (fully meshed), as shown in Figure 2. While holding C-3 in this position, place one of the large knobs on the shaft so that the white lines on the skirt of the knob point to "O". Secure the knob to the shaft by tightening the small screw in the knob against the shaft.

☐ Rotate the **MAIN TUNING** control shaft until the plates of C-2 are closed, as shown in Figure 2. While holding C-2 in this position, place the other large knob on the shaft so that its white lines point to the ends of the scale. Secure this knob to the shaft by tightening the small screw.

☐ Turn the **VOLUME** control shaft to its extreme counterclockwise position until a "click" is heard. Mount one of the small knobs on this shaft so its white line points to "OFF". Secure the knob to the shaft.

☐ Turn the **REGENERATION** control shaft to its extreme counterclockwise position. Mount a small knob on this shaft so its white line points to the extreme left hand mark on the scale. Secure the knob to the shaft.

☐ Mount another small knob on the **SW-BC** switch by tightening its screw against the flat side of the shaft.

☐ If desired, the last small knob may be mounted on the shaft of the **ANTENNA** control. While not absolutely necessary, this knob will be handy, especially when receiving short wave, since turning the bare shaft with your hand may affect the tuning of the Space Spanner. To mount the knob on this shaft, first remove the screw from the knob, then **GENTLY** force the knob onto the shaft.

UNDERSTANDING YOUR RECEIVER

What Is Radio?

The term **radio** is used to describe the sending and receiving of signals between two or more places without the use of wires. The signals are sent from the sending, or **transmitting**, station in the form of **radio waves**. A more technical term for radio waves is **electromagnetic radiation.**

Figure 8 shows a typical broadcasting and receiving system. As the announcer talks, his voice is changed into a weak **audio frequency (AF)** electrical signal by the microphone. The weak AF signal is fed into a **speech amplifier**, where it is made many times stronger. The strong AF signal from the speech amplifier is then fed into the **transmitter**, where it is changed into a strong **radio frequency (RF)** signal. The RF signal is then sent up the **transmitting antenna**, where it is sent out "over the air" in the form of radio waves, or, more technically, electromagnetic radiation.

The KNIGHT Space Spanner

At the **receiver**, the **receiving antenna** "picks up" a small part of all the transmitted signals in the air. These signals are fed to the **RF Tuned Circuit** (see Figure 9) where the one desired signal is passed on to the

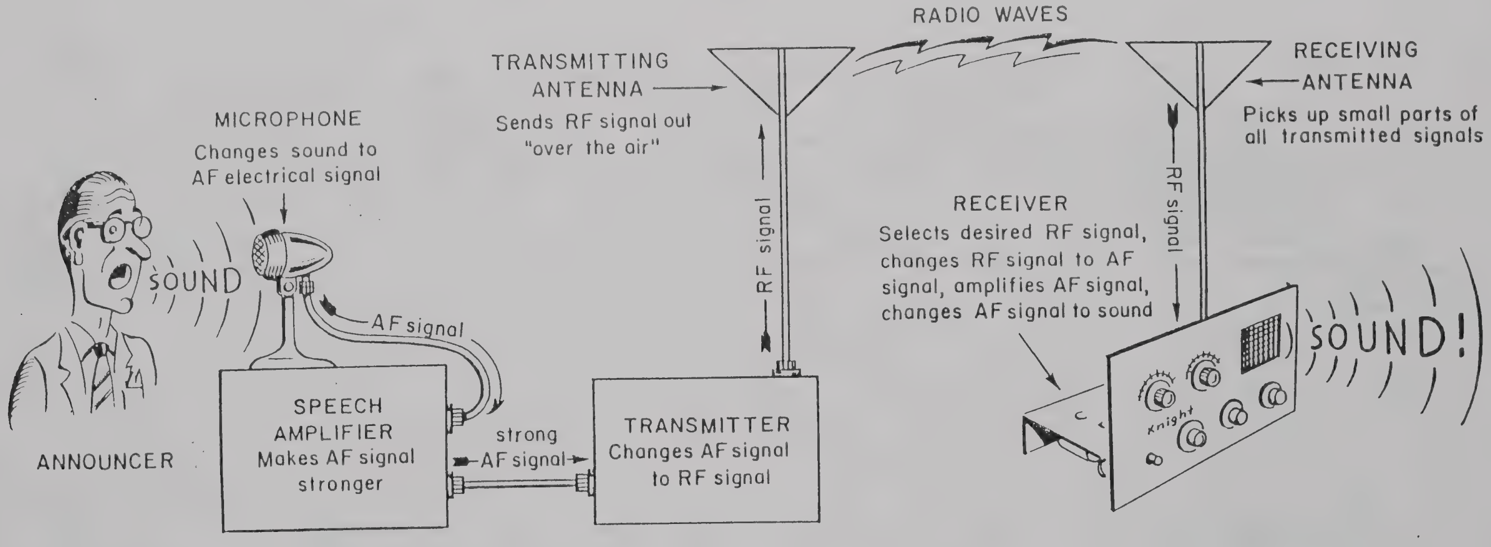

RADIO WAVES
TRANSMITTING ANTENNA
Sends RF signal out "over the air"
RECEIVING ANTENNA
Picks up small parts of all transmitted signals
MICROPHONE
Changes sound to AF electrical signal
RF signal
RF signal
RECEIVER
Selects desired RF signal, changes RF signal to AF signal, amplifies AF signal, changes AF signal to sound
SOUND
AF signal
SOUND!
SPEECH AMPLIFIER
Makes AF signal stronger
strong AF signal
TRANSMITTER
Changes AF signal to RF signal
ANNOUNCER
Knight

FIGURE 8. HOW RADIO MESSAGES ARE SENT AND RECEIVED

rest of the receiver, while the unwanted signals are "blocked-out". The **Detector** changes the selected RF signal to an AF signal. The **First** and **Second Audio Amplifiers** make the weak AF signal strong enough to "drive" the **speaker**. The strong AF signal out of the Second Audio Amplifier is coupled to the **speaker** through the **Output Transformer**. The speaker changes the AF electrical signal back into sound.

The History of Radio

Radio had its beginning way back in 1873, when Ulysses S. Grant was President of the United States. In this year an Englishman by the name of **James C. Maxwell** made a prediction that electromagnetic waves, or, as he called them, "ether" waves, could be sent from one place to another through the air, just as light rays were. However, Maxwell died without ever having tested his idea.

A young German scientist, **Heinrich Hertz**, worked on Maxwell's idea from 1885 to 1889. One day he announced that he had indeed succeeded in sending electromagnetic waves from one room to another in his laboratory in Karlsruhe, Germany. Hertz, however, did not pursue his discovery.

It remained for a young Italian engineer-inventor by the name of **Guglielmo Marconi** to bring radio communication to the attention of the world. In 1890 he began experiments on his father's estate to test Hertz' theory. His experiments led to the invention of an outfit for sending code messages from one place to another without the need of wires. Code messages were used because no one knew how to transmit voices and music by radio. This outfit, or transmitter, attracted the attention of Sir William Henry Preece, who encouraged Marconi to transfer his experiments to England. In 1899 Marconi came to the United States, where he used his method of communication to report the Presidential election of 1900, the year that Teddy Roosevelt was elected to his first term. In 1902 he succeeded in establishing transatlantic communication with Europe. In 1904 Marconi began a daily news service to ocean liners in the Atlantic.

LEARNING THE CODE

Marconi's method of communication is shown in Figure 10. This method is still the most widely used of all systems. In this system, a transmitter generates an RF signal at one radio frequency. The key, which is worked by the transmitting operator's hand, turns the RF signal on and off according to the International Morse Code. The transmitting antenna sends radio waves out over the air in short and long bursts, according to the way the transmitter is keyed. As shown, a short burst represents a

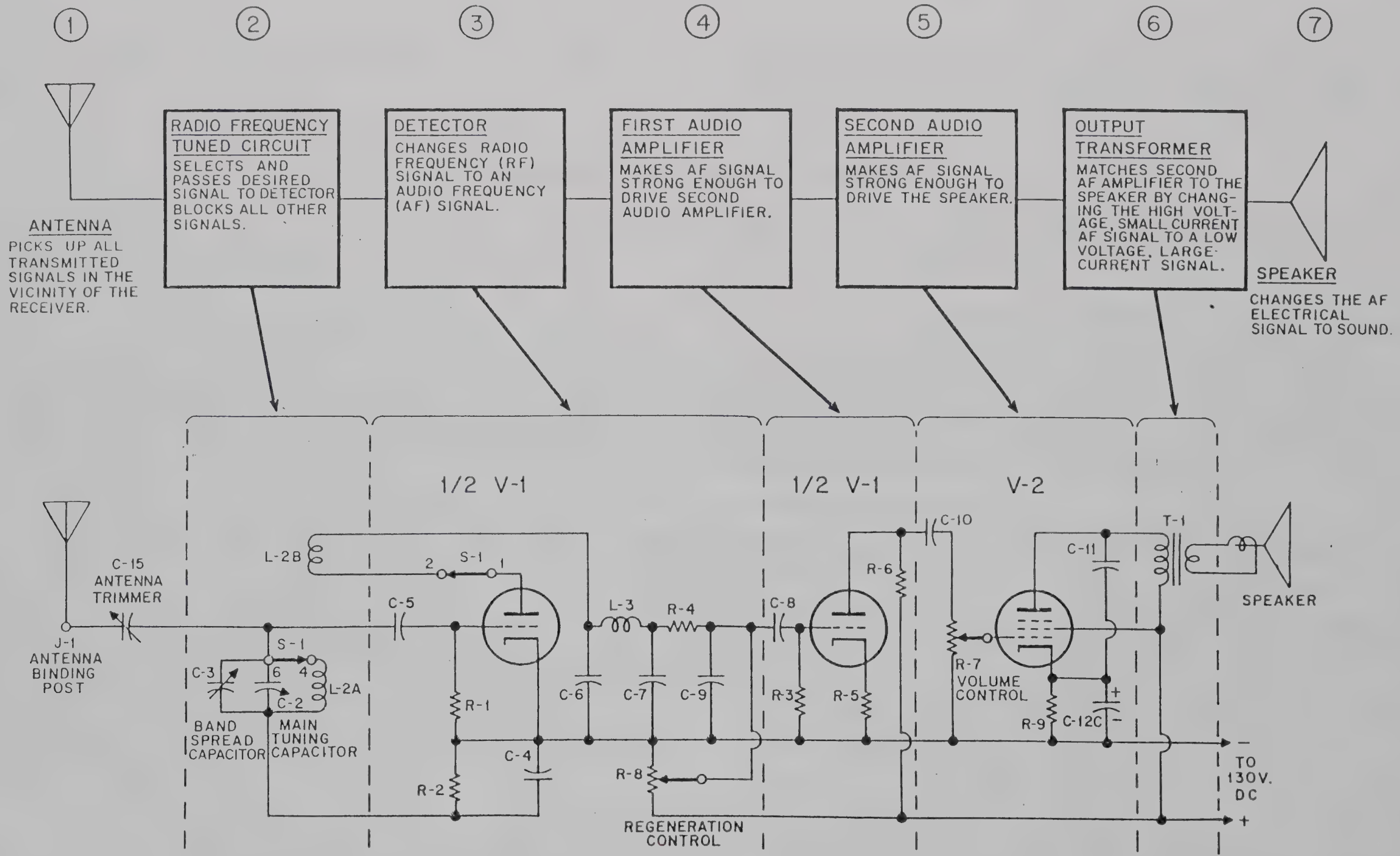

①
②
③
④
⑤
⑥
⑦
ANTENNA
PICKS UP ALL TRANSMITTED SIGNALS IN THE VICINITY OF THE RECEIVER.
RADIO FREQUENCY TUNED CIRCUIT
SELECTS AND PASSES DESIRED SIGNAL TO DETECTOR BLOCKS ALL OTHER SIGNALS.
DETECTOR
CHANGES RADIO FREQUENCY (RF) SIGNAL TO AN AUDIO FREQUENCY (AF) SIGNAL.
FIRST AUDIO AMPLIFIER
MAKES AF SIGNAL STRONG ENOUGH TO DRIVE SECOND AUDIO AMPLIFIER.
SECOND AUDIO AMPLIFIER
MAKES AF SIGNAL STRONG ENOUGH TO DRIVE THE SPEAKER.
OUTPUT TRANSFORMER
MATCHES SECOND AF AMPLIFIER TO THE SPEAKER BY CHANGING THE HIGH VOLTAGE, SMALL CURRENT AF SIGNAL TO A LOW VOLTAGE, LARGE-CURRENT SIGNAL.
SPEAKER
CHANGES THE AF ELECTRICAL SIGNAL TO SOUND.
1/2 V-1
1/2 V-1
V-2
C-15
ANTENNA TRIMMER
J-1
ANTENNA BINDING POST
L-2B
S-1
2
1
C-5
C-3
6
4
C-2
L-2A
BAND SPREAD CAPACITOR
MAIN TUNING CAPACITOR
R-1
R-2
C-4
C-6
L-3
R-4
C-7
C-9
R-8
REGENERATION CONTROL
C-8
R-3
R-5
R-6
C-10
R-7
VOLUME CONTROL
R-9
C-12C
+
-
C-11
T-1
SPEAKER
-
TO 130V. DC
+

FIGURE 9. HOW YOUR SPACE SPANNER WORKS

dot, and a long burst a dash. The receiving antenna picks up a small part of all transmitted signals. The receiver selects the desired signal, changes it into an AF signal of a single tone, and converts it to sound. A code message sounds like short and long bursts of a musical note.

You should consider the code simply as another means of conveying information. The spoken word is one method, the printed page another. Typewriting and shorthand are additional examples of conveying information. Learning the code is as easy as learning to type.

In order for a person to understand code messages, he must first learn the code. This code is given in the chart on page 20. Although it is possible to learn the code by listening to it on the radio, usually it is more practical to use a Code Practice Oscillator, or Code Records which may

be played on your phonograph, since the code heard on your receiver is too fast for a beginner.

Take a few characters at a time. Learn them thoroughly in diDAH language before going on to new ones. If someone who is familiar with code can be found to "send" to you, either by whistling or by means of a Code Practice Oscillator, ask him to help you. Usually he will be more than glad to do so.

OPERATING YOUR SPACE SPANNER

Power Requirements

Your Space Spanner can be operated on any alternating current (AC) or direct current (DC) whose voltage is from 105 to 125 volts.

Antenna Requirements

The importance of a good antenna for satisfactory reception cannot be over-emphasized. For the Broadcast Band (BC) a few feet of wire strung around the room will probably give satisfactory results. For the Short-Wave Band (SW), however, a good outside antenna should be used if long distance reception is expected. Such an antenna should be between 37½ and 75 feet long, and should be mounted as high off the ground as possible. An excellent, inexpensive antenna kit, complete with instructions, is listed under ACCESSORIES in the Parts List.

Working the Controls

Your Space Spanner, while not difficult to operate, requires some practise before peak performance, particularly on short wave, can be realized. The Space Spanner covers the Broadcast Band (the dial for the broadcast band is below the knob) from 540 to 1700 kilocycles (KC), and the Short-Wave Band (the scale above the knob) from 6 to 17 megacycles (MC). We suggest that you learn to operate this receiver on the Broadcast Band before attempting to receive short-wave signals.

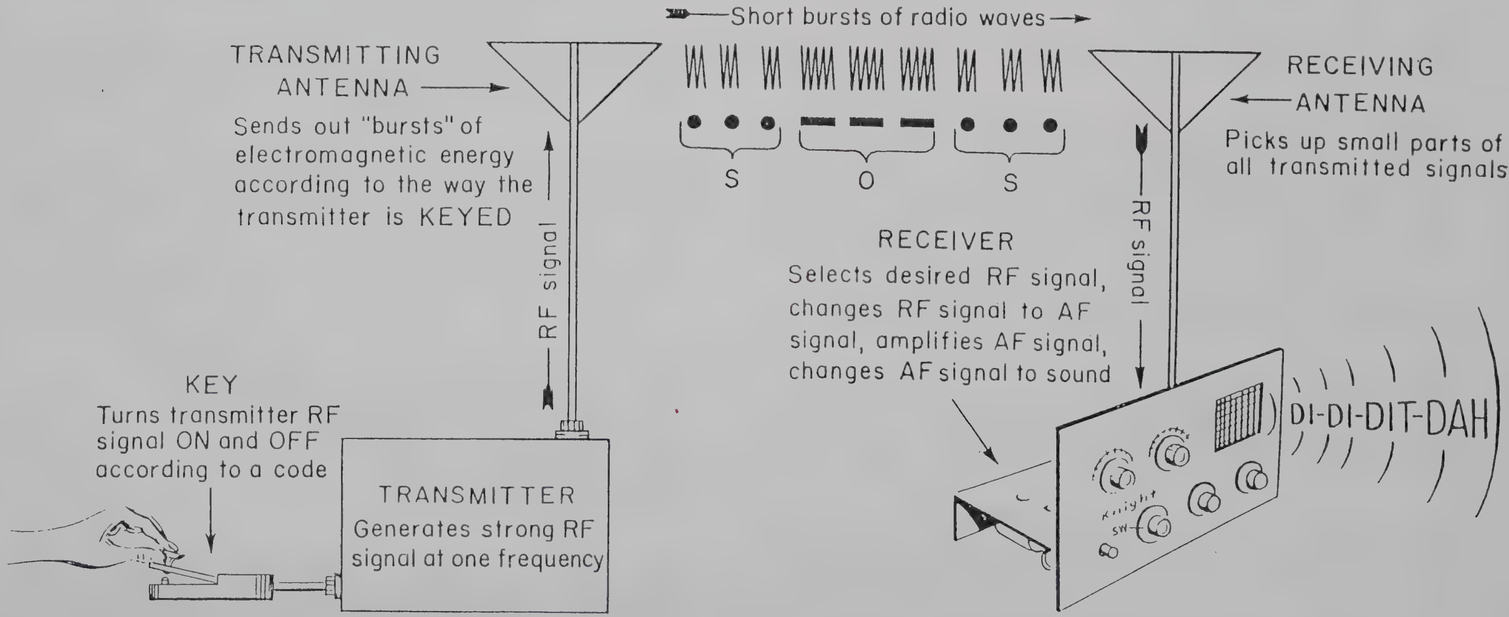

Short bursts of radio waves
TRANSMITTING ANTENNA
Sends out "bursts" of electromagnetic energy according to the way the transmitter is KEYED
RF signal
S
O
S
RECEIVING ANTENNA
Picks up small parts of all transmitted signals
RF signal
RECEIVER
Selects desired RF signal, changes RF signal to AF signal, amplifies AF signal, changes AF signal to sound
KEY
Turns transmitter RF signal ON and OFF according to a code
TRANSMITTER
Generates strong RF signal at one frequency
Knight
SW
DI-DI-DIT-DAH

FIGURE 10. RADIO COMMUNICATION USING CODE

Plug the tubes into their respective sockets, as shown in Figure 2. Mount your Space Spanner in the cabinet with two #4x¼" self-tapping screws. Turn the **VOLUME** control fully counterclockwise until a "click" is heard. Plug the line cord into a power outlet.

CAUTION: NEVER TOUCH ANY PART OF THE WIRING WHILE THIS RECEIVER IS PLUGGED INTO A POWER OUTLET. NEVER USE OR TEST THE SPACE SPANNER ON OR NEAR A GROUNDED METAL BENCH, RADIATOR, SINK OR OTHER GROUNDED METAL OBJECT. SERIOUS BODILY INJURY OR PROPERTY DAMAGE MAY RESULT IF THIS WARNING IS NOT HEEDED.

The regenerative detector in your KNIGHT Space Spanner is capable of extremely high **selectivity** (selectivity is the ability of a receiver to pass only one station and reject all others). The selectivity of this receiver is affected by the following factors:

1. Antenna length
2. Antenna coupling to the receiver
3. Amount of regeneration
4. Inductance to capacity ratio of the RF Tuned Circuit

Items 2, 3, and 4 in the above list are controllable from the front panel. The **ANTENNA** control varies the coupling between the antenna and the receiver. The **REGENERATION** control varies the amount of regeneration. The **MAIN TUNING** and **BANDSPREAD** controls vary the inductance to capacity ratio of the RF Tuned Circuit.

Since each of these controls interacts with the other, when the receiver is tuned with the **MAIN TUNING** and **BANDSPREAD** controls, the **ANTENNA** and **REGENERATION** controls will have to be changed.

A typical tuning procedure for receiving a Broadcast Band station is as follows:

SEE FIGURE 11.

Set the **SPEAKER-PHONES** switch on the rear of the chassis in the **SPEAKER** (up) position. Connect the antenna to the **ANTENNA** binding post on the rear of the chassis. Turn the **REGENERATION** control to its extreme clockwise position. Set the **SW-BC** switch to the **BC** position. Turn the **ANTENNA** control clockwise until it is all the way "in", then turn it counterclockwise two full turns. Set the **BANDSPREAD** control at 50. Turn the **VOLUME** control to its extreme clockwise position. Allow the Space Spanner to "warm up" for a few minutes.

After the receiver is warmed up, rotate the **MAIN TUNING** control throughout its range. You should hear indications of signals being received. These ordinarily are loud whistles. **PLEASE NOTE:** If the power being used by you is direct current (DC), you may not hear these whistles. Should this happen, pull the plug out of the power outlet, reverse it, and plug it back in. If you rotate the **MAIN TUNING** control very slowly, the whistle will start at a high pitch, fall to an increasingly lower pitch, pass through zero (no sound at all), and again rise toward a high pitch as you tune past a particular signal.

Set the **MAIN TUNING** control to one of the whistles, so that the whistle is at a low pitch. The pitch may be difficult to control with the **MAIN TUNING** control. If so, lower the pitch by rotating the **BANDSPREAD** control to the right or left.

Reduce the setting of the **REGENERATION** control to about "3 o'clock". If the whistle disappears when the **REGENERATION** control is set at 3 o'clock, slowly turn the **ANTENNA** control counterclockwise until the whistle just re-appears. Now, very slowly rotate the **ANTENNA** control clockwise until the whistle just disappears.

During this tuning procedure you may reduce the setting of the **VOLUME** control so that the sound is at a pleasing level. The setting of the **VOLUME** control has no effect on the tuning of the receiver.

If the whistle does not disappear when the **REGENERATION** control is set at 3 o'clock, very slowly turn the **ANTENNA** control clockwise until it just disappears.

If you cannot make the whistle disappear after turning the **ANTENNA** control clockwise one full turn, return the **ANTENNA** control to its original position. Reduce the setting of the **REGENERATION** control to less than 3 o'clock, but not so much that the whistle disappears completely. Eliminate the whistle with the **ANTENNA** control. It may be necessary to re-adjust the **MAIN TUNING** control after properly adjusting the **ANTENNA** control.

The Space Spanner now is adjusted for best voice and music reception. If the program sounds "mushy", reduce the setting of the **REGENERATION** control very slightly.

The point to remember when tuning the Space Spanner is this: If the **ANTENNA** control is turned too far clockwise, the antenna will load the receiver excessively. This will result in decreased selectivity, perhaps even to the extent where you will hear more than one station at a time. If the **ANTENNA** control is turned too far counterclockwise the received signal will be weak.

The setting of the **ANTENNA** control will not be the same across the Broadcast Band. It should be adjusted for any station so that best reception is obtained with the **REGENERATION** control set between 12 and 3 o'clock.

Short-wave reception is more critical, hence more care will have to be

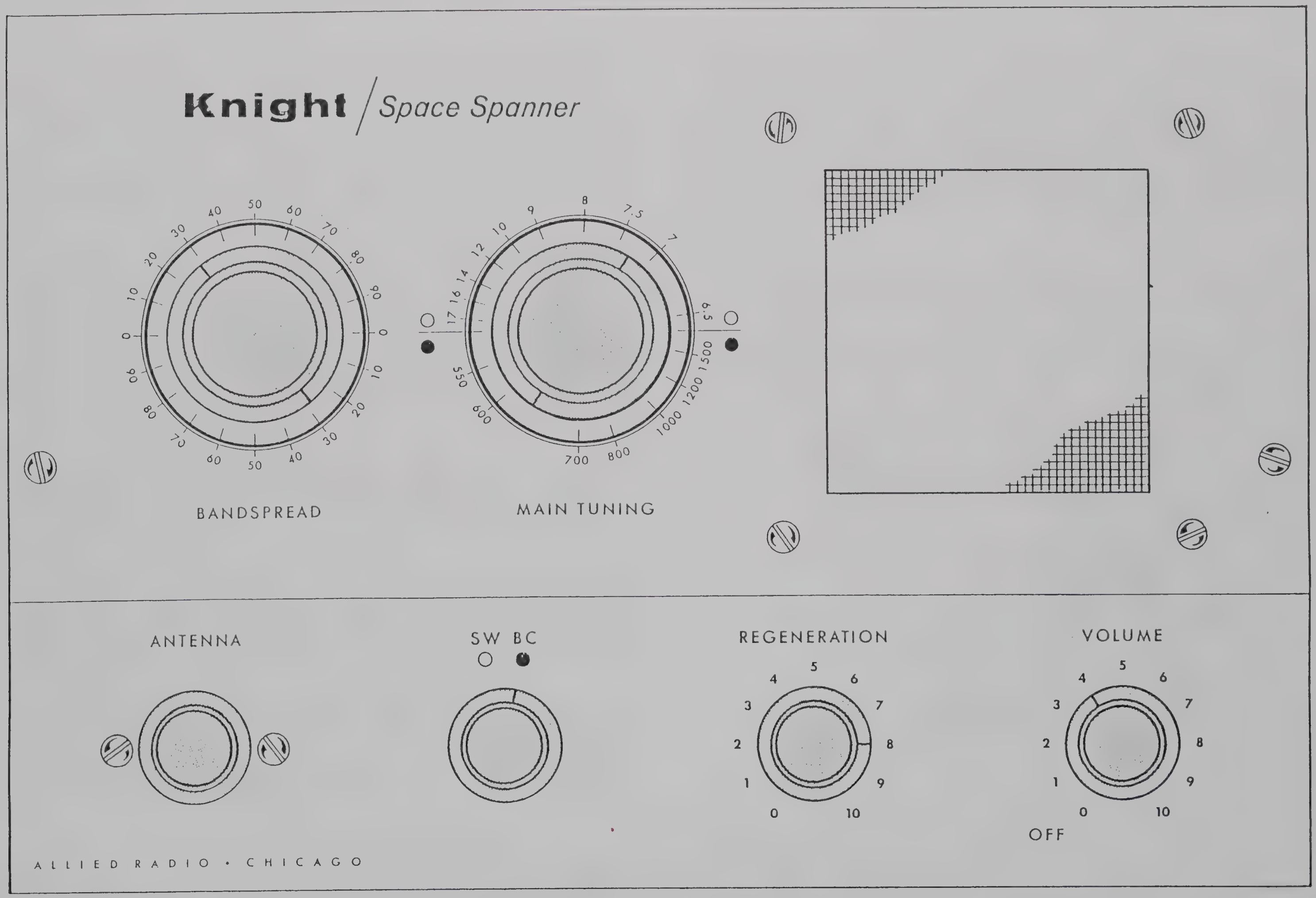


FIGURE 11. FRONT PANEL CONTROLS

exercised when tuning in a station. To receive short-wave signals, set the **SW-BC** switch at **SW**. Once again, set the **REGENERATION** control at about 3 o'clock and adjust the **ANTENNA** control to the point just below the whistling condition for voice reception. For code reception, set the **ANTENNA** control to the point where the code is heard as a series of whistles. Remember, if the **REGENERATION** control is advanced past 3 o'clock, the selectivity of the receiver will be reduced. This setting is especially critical on the Short-Wave Band because the stations are so close together.

It is likely that the antenna used will adversely affect the reception of short-wave signals at one or more points throughout the Short-Wave Band. This will show up as an abrupt stopping of the whistle as the receiver is tuned past a certain point. When this happens, reduce the setting of the **ANTENNA** control slightly, until the whistle again appears. When the receiver is tuned away from this point, the **ANTENNA** control must again be advanced. This condition is quite normal—it is simply the result of the antenna absorbing more energy from the Detector than the Detector can deliver. Reducing the coupling between the receiver and the antenna corrects the condition.

At the high end of the Short-Wave Band, extreme care must be exercised to make certain that the **REGENERATION** control is advanced just far enough to produce the normal whistle. If it is advanced too far, a loud "hiss" will be heard. When this happens, the selectivity and sensitivity of the receiver will be greatly reduced.

If the Space Spanner is used so that it whistles for code (CW) reception, it must be remembered that the antenna becomes an active part of the Detector circuit. If the antenna swings in the wind, the pitch of the received note will vary. This is normal, however, it is important to make sure that the antenna is reasonably clear of all other objects.

Should you wish to listen to your Space Spanner with earphones rather than with the speaker, use phones that have an impedance of 1,000 ohms or more. A good headset is listed in the Parts List under **ACCESSORIES**. To use earphones, merely plug them into the pin jacks on the rear of the chassis and set the **SPEAKER-PHONES** switch at **PHONES** (down).

The Ionosphere and Radio Reception

You may wonder why at some times you can hear a particular station, while at other times it is impossible to hear it. This condition can best be explained by referring to Figure 12.

In the figure, the tower at "A" is the transmitting antenna, while the towers labeled "B" and "C" are receiving antennas. As shown, radio waves go out in all directions from the transmitting antenna. These waves are labeled "a", "b", and "e".

Let's take wave "a" first. This is known as the ground wave because it hugs the ground, and is rapidly absorbed by it. The ground wave is present in the same locations at all times when the transmitter is operating. Any receiver located within the area of the ground wave, such as that at "B", will always receive the transmitted signal. This is why you always receive the programs broadcast by your local radio stations. The ground wave completely disappears after it has traveled a certain distance. A receiver located outside the range of the ground wave, such as that at "C", is not affected by it.

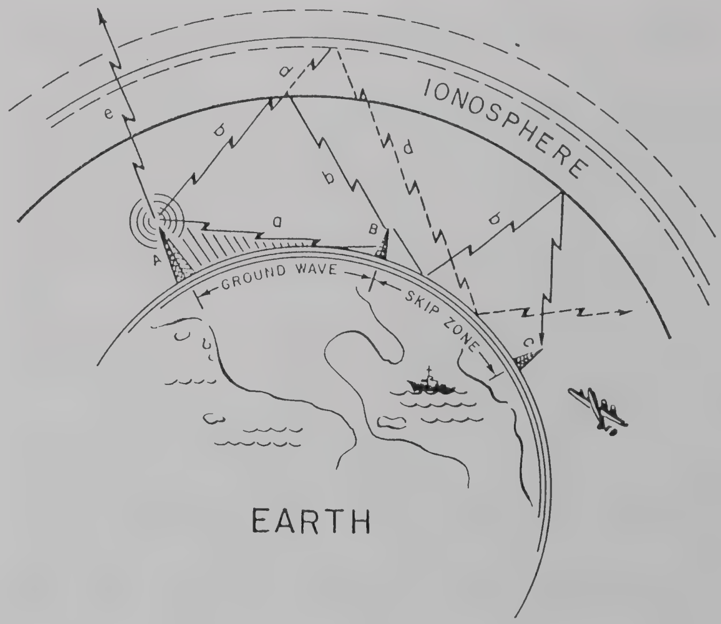


FIGURE 12. EFFECT OF THE IONOSPHERE ON RADIO WAVES

At the same time that the ground wave is being transmitted, other waves, called sky waves, are also being sent out. Referring to sky wave "b", notice that it is transmitted upward, but not straight up. This wave continues on up until it reaches a layer of particles up in the sky called the ionosphere. Here the wave does a peculiar thing. It bounces off the ionosphere back toward the Earth. If it bounces just right, receiver "B" will pick it up. Going a bit further, when this wave hits the Earth, it may bounce right back up toward the ionosphere. When it reaches the ionosphere, it bounces back toward the Earth.

Receiver "C" now picks up the transmitted signal because the sky wave has bounced right on to its antenna. It seems, then, that receiver "C" should always be able to "hear" transmitter "A". This would be true if the ionosphere stayed in one place, as indicated by solid curved lines above the Earth. However, at different times of the day, and at different seasons of the year, the ionosphere shifts up and down. Suppose that the ionosphere shifts up, as indicated by the broken curved lines. Now the sky wave "b" must go higher before it bounces back toward the Earth (broken wave "d"). Consequently, it hits the Earth farther away from the transmitter and misses receiver "B" entirely. However, the ground wave still reaches "B", and it still hears the transmitter. When wave "d" bounces back up toward the ionosphere, it also misses receiver "C". Because the ground wave does not reach "C", he cannot hear the program being transmitted. This explains why you sometimes can, and sometimes cannot, hear a particular station.

Wave "e" shows what happens when a radio wave leaves the antenna straight up. It goes right through the ionosphere and never again reaches the Earth.

When To Listen

Under normal conditions, with patience and practice, it's possible to hear stations from all over the world in a single evening — at times even within a few minutes! All you need is your Space Spanner, a simple antenna, a knowledge of **where** and **when** to listen — plus persistence.

International short-wave radio is glamorous as well as educational. It provides a satisfying hobby. To some, perhaps, it's the feeling of "power" to reach out to the farthermost corners of the earth at the flick of a switch and the twirl of a knob!

Short-wave broadcasts enable you to learn first-hand what people in other countries have to say about current affairs, and what kinds of music and other entertainment they have. Many programs are sent in English for those who know no foreign languages, and in the various local languages for those who want to study languages as they are actually spoken in their respective countries.

Some short-wave enthusiasts are interested in receiving **QSL's** (verifications) from the stations to which they have listened. Others report their results to radio clubs; they get their big thrill from seeing their names in print credited with a fine "catch", perhaps, such as a "first-heard" on a new station. Still others try to build up a long list of stations heard, content that their records show a great amount of reception from all over the world.

Short-wave radio transmitters include land communications stations, maritime stations, aeronautical stations, amateur (ham) stations, and broadcasting stations. Of these, the broadcasting and amateur (ham) stations are of most interest to the **short-wave listener** (SWL). However, there are many other "specialties" to listen to such as code; commercial phones (international telephone and point-to-point communications — standard or inverted — or scrambled — speech); shipping and coastal radio; police, fire, and other local governmental agencies; plane and ground communications; weather station reports and contacts; special expeditions, and other unusual events.

Some SWL's like to listen for DX (distant reception) "the long way around" — which is a form of "freak" reception which is not normally heard.

By international agreement, each type of station is assigned certain bands for operations.

You'll find that the short-wave portions of the dial on your receiver are calibrated (marked off) in megacycles (MC); a megacycle is 1000 kilocycles (KC).

Short-wave stations operate in these megacycle bands — 5.95 to 6.20 MC; 7.10 to 7.30 MC; 7.0 to 7.3 MC amateur band; 9.50 to 9.80 MC; 11.70 to 12.00 MC; 14 to 14.3 MC amateur band; 15.10 to 15.45 MC. Some receivers indicate these bands in meters (m.)—such as the 49, 41, 40, 31, 25, 20, and 19 meter bands respectively. Thus, **megacycles refer to frequency; meters refer to wavelength.**

Reception conditions on each of the short-wave broadcast bands vary a lot at different times of the day and night, and also at different seasons of the year. It's important that you learn when to listen on each band.

In general, for SWL's in North America, the best reception on each of these bands during the fall and spring months should be:

The 6 MC band—Evening for Latin America and Europe.

The 7 MC bands—Late afternoon and **evening** for Europe. **Evening** and **early morning** for amateur stations.

The 9 MC band—Morning (6 to 8 a.m. **your local time**) for Asia and Australia; **afternoon** for Europe and Africa; **evening** for Europe and Latin America.

The 11 MC band—Morning (6 to 9 a.m. **your local time**) for Asia and Australia; **afternoon** for Europe and Africa; **evening** for Latin America.

The 14 MC band—late morning and **afternoon** for amateur stations.

The 15 MC band—Morning and **afternoon** for Europe and North America; **evening** for North and South America.

During the winter months, the best bands for evening reception are lower than during the fall and spring. For instance, the 9 MC band becomes poor for reception from Europe during the evening hours, and the 6 MC band becomes the best band for European reception.

In the summer months, the best evening reception shifts to the higher bands. Evening reception from Europe becomes good in the 11 MC band, although the 9 MC band remains good for reception from that area.

Year-around DX (distant reception) bands are the 9 MC and 11 MC bands, although consideration there must be given to receiving different parts of the world best in summer or winter.

The expected reception just outlined is for normal conditions. The factors which affect long-distance radio transmissions vary from day to day. On some days, for instance, reception will be quite good, but at times, generally for periods of several consecutive days, transmission conditions will be "disturbed" and only the more powerful stations can be heard.

But don't get discouraged because normal conditions will return after the disturbance has ended, and reception will again be good.

Here's a special caution: Short-wave broadcasting stations often change their schedules and/or frequencies with little or no prior notice. Always be on the alert for announcements of such changes.

THE INTERNATIONAL MORSE CODE

The important thing when beginning to study code is to think of it as a language of sound, never as combinations of dots and dashes. It is easy to "speak" code by using "dit" for dots and "DAH" for dashes, so that "A" would be "diDAH". The "t" at the end of "dit" is dropped except at the end of a character. The sound "di" should be sharp; a code character like the number "5" should sound like a machine-gun burst- dididididit! Stress each "DAH" equally; they are capitalized in this chart because they should be slightly accented and drawn out.

Learn the code by **listening** to it. **Don't think about speed to start;** the first requirement is to learn the characters to the point where you can recognize each of them without any hesitation whatsoever. Concentrate on any difficult letters. Learning the code is not hard—it merely requires time and a little effort.

CHARACTER	CODE	PRONUNCIATION OF CODE	PHONETIC LETTER
A	• —	diDAH	Able
B	— • • •	DAHdididit	Baker
C	— • — •	DAHdiDAHdit	Charlie
D	— • •	DAHdidit	Dog
E	•	dit	Easy
F	• • — •	didiDAHdit	Fox
G	— — •	DAHDAHdit	George
H	• • • •	didididit	How
I	• •	didit	Item
J	• — — —	diDAHDAHDAH	John
K	— • —	DAHdiDAH	King
L	• — • •	diDAHdidit	Love
M	— —	DAHDAH	Mike
N	— •	DAHdit	Nan
O	— — —	DAHDAHDAH	Oboe
P	• — — •	diDAHDAHdit	Peter
Q	— — • —	DAHDAHdiDAH	Queen
R	• — •	diDAHdit	Roger
S	• • •	dididit	Sugar
T	—	DAH	Tare
U	• • —	didiDAH	Uncle
V	• • • —	dididiDAH	Victor
W	• — —	diDAHDAH	William
X	— • • —	DAHdidiDAH	X-ray
Y	— • — —	DAHdiDAHDAH	Young
Ƶ	— — • •	DAHDAHdidit	Zebra

CHARACTER	CODE	PRONUNCIATION OF CODE
1	• — — — —	diDAHDAHDAHDAH
2	• • — — —	didiDAHDAHDAH
3	• • • — —	dididiDAHDAH
4	• • • • —	didididiDAH
5	• • • • •	dididididit
6	— • • • •	DAHdidididit
7	— — • • •	DAHDAHdididit
8	— — — • •	DAHDAHDAHdidit
9	— — — — •	DAHDAHDAHDAHdit
0	— — — — —	DAHDAHDAHDAHDAH
Period (.)	• — • — • —	diDAHdiDAHdiDAH
Comma (,)	— — • • — —	DAHDAHdidiDAHDAH
Question mark (?)	• • — — • •	didiDAHDAHdidit
Double dash (—)	— • • • —	DAHdididiDAH
Fraction bar (/)	— • • — •	DAHdidiDAHdit
Invitation to transmit	— • —	DAHdiDAH
Error	• • • • • • • •	didididididididit
Wait	• — • • •	diDAHdididit
End of message	• — • — •	diDAHdiDAHdit
End of work	• • • — • —	dididiDAHdiDAH

ALLIED'S SERVICE FACILITIES

In the event that the kit does not operate properly, please write our Kit Department with full details and include the stock number and the date of purchase of the kit. We may be able to determine any wiring error or replace a component which may be at fault.

This wired KNIGHT kit may be returned for inspection within 1 year after purchase for a special service charge of $2.50. Parts within the standard EIA 90-day warranty period will be replaced without charge for the parts. An additional charge will be made for parts damaged in construction or because of a wiring error, or for parts which are beyond the 90-day warranty period. After the one-year period, service charges, plus cost of parts, are based on the length of time required to repair the unit.

PLEASE NOTE: KITS WIRED WITH ACID CORE SOLDER OR ACID FLUX ARE NOT ELIGIBLE FOR REPAIR OR SERVICE AND WOULD HAVE TO BE RETURNED NOT REPAIRED AT YOUR EXPENSE.

Allied's facilities primarily provide an inspection and trouble-shooting service. Kits not completed, which require extensive work, will be returned collect with a letter of explanation.

If you must return this kit, pack it well. Use the original packing carton and use cushioning material around the front panel. Send the kit prepaid and insured. We will return the repaired kit to you C.O.D. as soon as repairs are completed. If you wish to save C.O.D. fees, your advance remittance may be enclosed for standard repair charges plus transportation costs. Any excess remittance will be refunded.

ALLIED'S GUARANTEE ON KNIGHT KITS

The designs and components selected for KNIGHT kits represent over a quarter of a century of experience in kit development. KNIGHT kits are easy to assemble even for the beginner. Instructions are complete, panels are drilled, the chassis is punched and formed, and every last part is included as listed.

Allied extends these firm guarantees on KNIGHT kits:

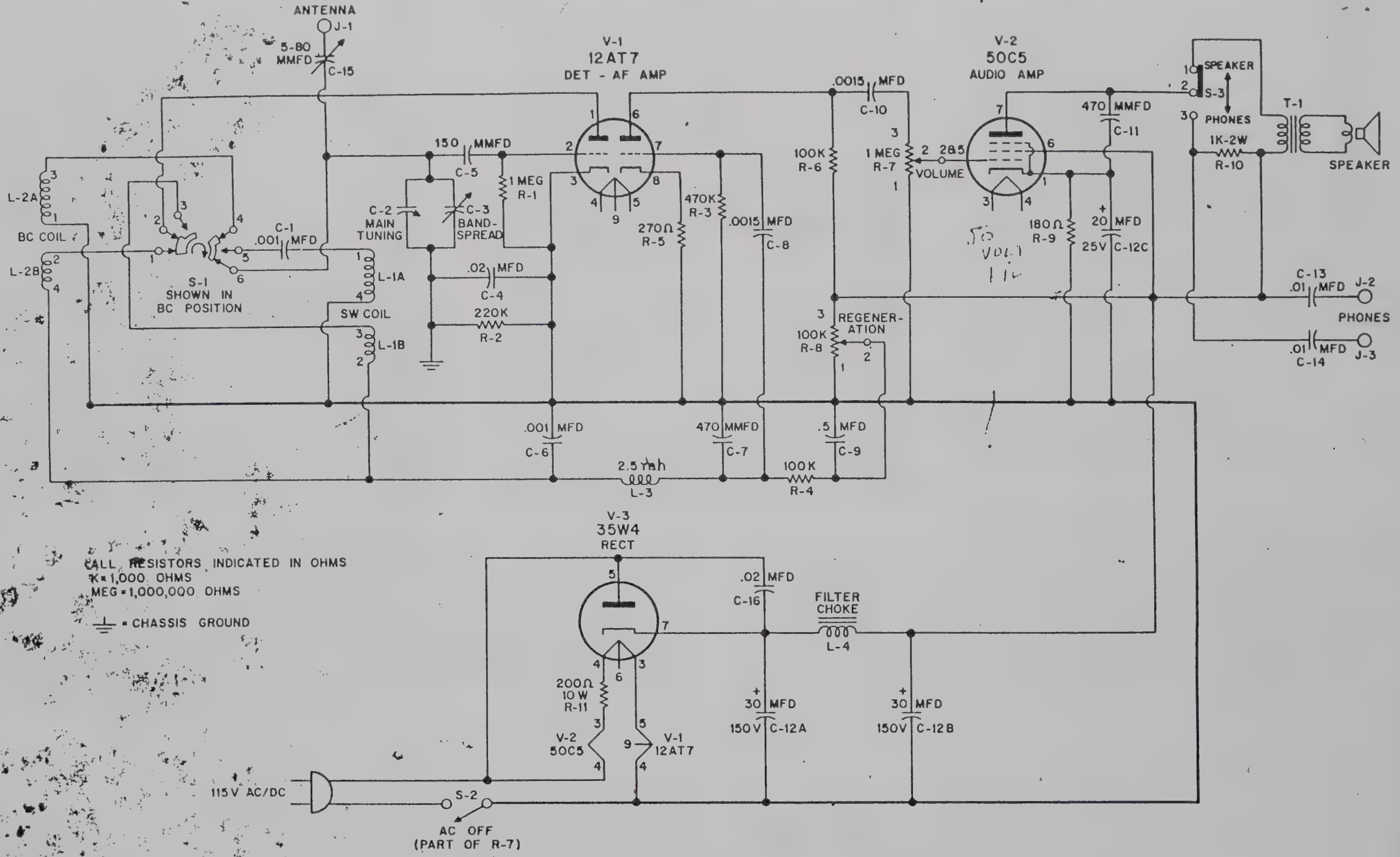
We guarantee that the circuits on all KNIGHT kits have been carefully engineered and tested.

We guarantee that only high-quality components are supplied. All parts are covered by the standard EIA 90-day warranty. Any faulty components will be replaced prepaid and without charge if reported to us within the warranty period. We reserve the right to request the return of defective parts.

If your kit was shipped by parcel post and is received in a damaged condition, please write us at once describing the state in which the shipment was received. If your kit was part of a Railway Express shipment that was damaged in transit, please notify the Railway Express agent at once and then write us.

The efficiently engineered KNIGHT kits are moderately priced. When you buy a KNIGHT kit you get the best in design, quality, and value. Recommend KNIGHT kits to your friends.

Socket 12V in Handbook.
the 6CA5 6V.
92
12CA5 12V will fit so



ALL RESISTORS INDICATED IN OHMS
K=1,000 OHMS
MEG=1,000,000 OHMS

⏚ = CHASSIS GROUND

FIGURE 13. SCHEMATIC DIAGRAM, KNIGHT SPACE SPANNER

PARTS LIST FOR THE KNIGHT SPACE SPANNER

Symbol Number	Description	Part No.
C-1	Capacitor, 1,000 MMFD (.001 MFD) ±10%, 500 V, mica	296002
C-2	Capacitor, **MAIN TUNING**, 400 MMFD max. variable	281003
C-3	Capacitor, **BANDSPREAD**, 13.5 MMFD max. variable	281015
C-4	Capacitor, .02 MFD, 600V, ceramic disc, GMV	296009
C-5	Capacitor, 150 MMFD, 600 V, ceramic disc, ±20%	276158
C-6	Capacitor, .001 MFD, 600 V, ceramic disc, GMV	276016
C-7	Capacitor, 470 MMFD, 600 V, ceramic disc, ±20%	276478
C-8	Capacitor, .0015 MFD, 600 V, ceramic disc, GMV	276157
C-9	Capacitor, 0 5 MFD, 400 V, paper	245054
C-10	Capacitor, .0015 MFD, 600 V, ceramic disc, GMV	276157
C-11	Capacitor, 470 MMFD, 600 V, ceramic disc, ±20%	276478
C-12	Capacitor, electrolytic, 30-30-20 MFD @ 150-150-25 V	213301
C-13	Capacitor, .01 MFD, 600 V, ceramic disc, GMV	276015
C-14	Capacitor, .01 MFD, 600 V, ceramic disc, GMV	276015
C-15	Capacitor, **ANTENNA** trimmer, 5-80 MMFD	283000
C-16	Capacitor, .02 MFD, 600 V, ceramic disc, GMV	296009
J-1	Binding post, black, **ANTENNA** connector	533002
J-2, J-3	Dual pin jack, **PHONE** connector	502227
L-1	Short wave coil	111201
L-2	Broadcast coil	111202
L-3	RF choke, 2.5 mh	151001
L-4	Filter choke	140003

Note: When ordering resistors, give complete description and part number.

Symbol Number	Description	Part No.
R-1	Resistor, 1 megohm, ½ watt	301105
R-2	Resistor, 220K ohms, ½ watt	300224
R-3	Resistor, 470K ohms, ½ watt	300474
R-4	Resistor, 100K ohms, ½ watt	301104
R-5	Resistor, 270 ohms, ½ watt	301271
R-6	Resistor, 100K ohms, ½ watt	301104
R-7	Potentiometer, **AC OFF-VOLUME** control, 1 megohm, log taper with SPST switch attached	890005
R-8	Potentiometer, **REGENERATION** control, 100K ohms, linear taper	390101
R-9	Resistor, 180 ohms, ½ watt	301181
R-10	Resistor, 1,000 ohms, 2 watts	306102
R-11	Resistor, 200 ohms, 10 watts	374001
S-1	**SW-BC** Bandswitch	432101
S-3	**SPEAKER-PHONES** Switch	431101
S-2	**ON-OFF** Switch	Part of R-7
T-1	Output Transformer	Part of speaker
TS-1	Terminal strip, 5-terminal	440501
TS-2	Terminal strip, 2-terminal	440201
V-1	**DETECTOR—1st AUDIO AMP.** tube 12AT7	611013
V-2	2nd **AUDIO AMPLIFIER** tube 50C5	610026
V-3	**RECTIFIER** tube 35W4	610029

Quantity	Description	Part No.
1	Cabinet	702008
1	Chassis	461302
1	Cord, line, with plug	802001
1	Grill, perforated	731015
4	Grommet, rubber, small	830001
3	Grommet, rubber, large	830200
4	Knob, small	764501
2	Knob, large	764303
5	Lug, solder	553002
1	Manual, instruction	750003
4	Nut, 4-36 hex (Small)	570230
18	Nut, 6-32 hex (medium)	570340
1	Nut, 8-32 hex (large)	570440
6	Nut, ⅜" hex, control mtg. (very large)	570840
5	2" red wire	801002
9	3" orange wire	801003
6	4" yellow wire	801004
2	5" green wire	801005
1	8" gray wire	801008
36"	Rosin Core Solder	930036
1	6" Bare wire	806006
1	Panel, front	462613
2	Screw, #4x¼" self-tapping	562292
4	Screw, 4-36 x ⅜" (long, thin)	560234
7	Screw, 6-32 x ⅛" (short)	560340
18	Screw, 6-32 x ¼" (medium)	560342
2	Spacer, ceramic, threaded	940004
1	Spaghetti, 6" length	812001
1	Speaker, 4" PM, with output transformer attached	730003
2	Socket, for 7-pin tube	501070
1	Socket, for 9-pin tube	501090
1	Washer, #8 fiber, flat	590400
1	Washer, #8 fiber, shouldered	591401
1	Washer, ⅜" internal tooth lock	582700

TOOLS NEEDED FOR CONSTRUCTION

Stock No.	Description	Price*
46N852	Soldering pencil	$5.26
50N132	6" longnose pliers	1.54
45N796	6" screwdriver	.72
50N133	5" diagonal cutters	1.34

ACCESSORIES YOU MAY WANT

Stock No.	Description	Price*
59Y110	Headset, 2,000 ohms impedance	$2.00
83Y100	Antenna kit	1.03

* **All prices subject to change without notice.**

VOLTAGE CHART

All measurements made with a 20,000 ohms-per-volt VOM from terminal 1 of S-2 to point specified. All readings given in DC volts unless otherwise specified. **MAIN TUNING** control set fully clockwise; **BANDSPREAD** at "O"; **SW-BC** switch at "BC"; **REGENERATION** control fully clockwise; **AC OFF-VOLUME** control just turned on (volume at minimum); **SPEAKER-PHONES** switch at SPEAKER; antenna disconnected.

TUBE	PIN								
	1	2	3	4	5	6	7	8	9
V-1 12AT7	42	—.3	0	0	11AC	38.5	—.2	.25	NC
V-2 50C5	8.5	0	65AC	110AC	NC	120	115		
V-3 35W4	120	NC	11AC	42AC	110AC	NC	135		

RESISTANCE CHART

All controls set as stated in Voltage Chart. **POWER DISCONNECTED**. Readings with (*) taken between point specified and pin 7 of V-3. All other readings taken between point specified and terminal 1 of S-2. All readings given in ohms. K = 1,000 ohms. M = 1,000,000 ohms. NC = No connection.

TUBE	PIN								
	1	2	3	4	5	6	7	8	9
V-1 12AT7	100K*	1.1M	0	0	[illegible]	100K*	450K	250	NC
V-2 50C5	180	23	250	300	NC	330*	500*		
V-3 35W4	300*	NC	12	50	300	NC	0*		

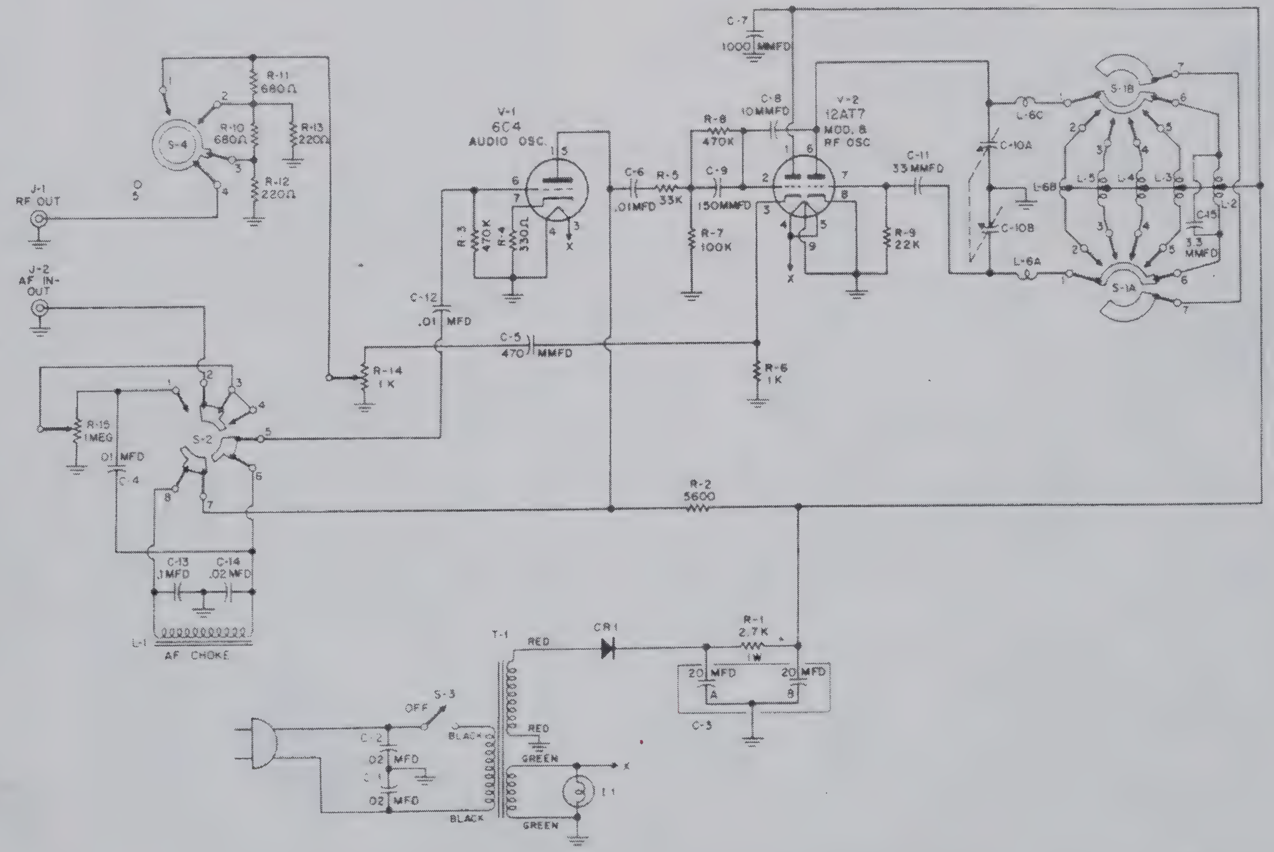


FIGURE 15. SCHEMATIC DIAGRAM OF THE KNIGHT RF SIGNAL GENERATOR KG-650

KNIGHT 2-TUBE “DX-ER”

The 2-Tube “DX-ER” is a dependable battery operated short-wave receiver which can be built quickly and easily. The tuning range is 9.5 to 550 meters when used with proper coils, covering the important foreign and domestic 'phone and code Amateur bands, as well as regular standard broadcast programs.

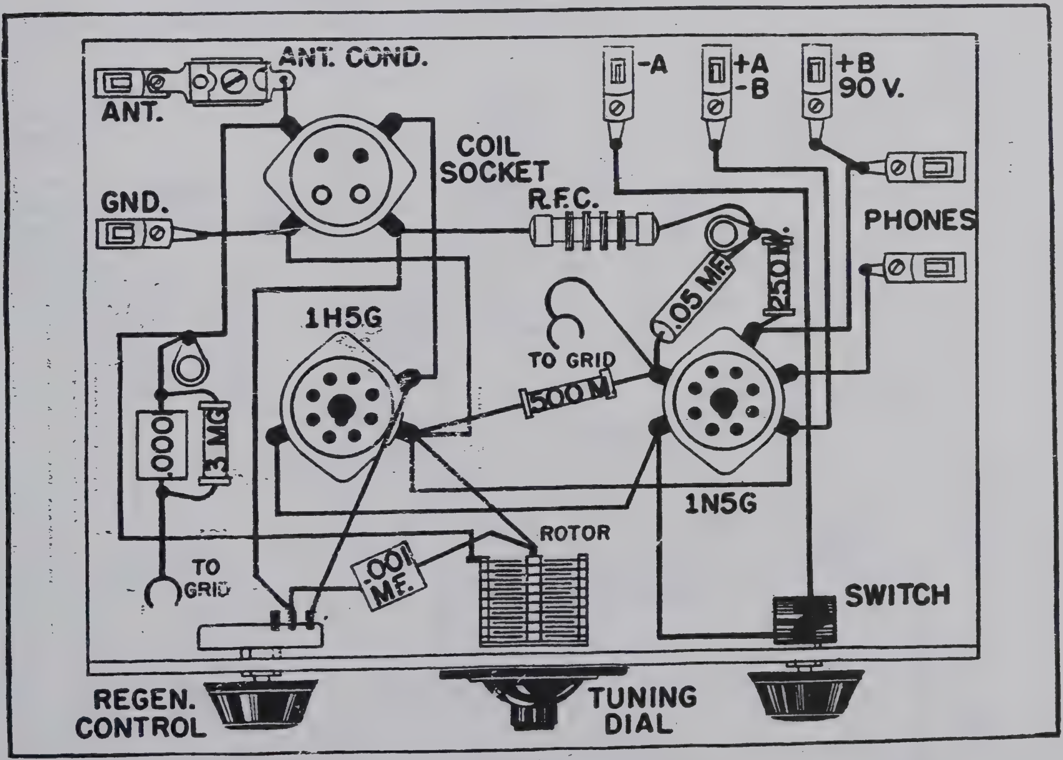
Before you begin to wire, you should mount all the parts as indicated on the pictorial diagram. This is extremely important for effective results. You can then start the wiring, following the schematic diagram and checking your work from time to time with the pictorial diagram. As you proceed, trace the completed connections with a colored pencil. This will help you to remember exactly which connections have already been made.

After the set has been wired and one of the coils and the two 1.4 volt tubes are in place, connect the “A” battery and notice the filament glow in the tubes. This will serve as a safety check to see if the filaments are wired correctly. No glow indicates that an error has been made in the filament circuit. When the filament glows connect the “B” battery and insert the headphones into the proper Fahnestock clips.

Now test the set to see if it will regenerate. Advance the regeneration control to the right, and a hiss will be heard. If you do not hear this hiss, check the coil socket and the “B” batteries to see that they are wired correctly.

Next, connect the antenna and ground. With these in place and the regeneration control just below oscillation (hissing point), turn the tuning control and you will receive several stations. You will find that adjusting the antenna trimmer will help a great deal. The antenna condenser should be adjusted so that the detector tube will oscillate at all points on the tuning dial. The point of adjustment depends entirely upon the degree of absorption of the antenna circuit from the tuning circuit. Once the trimmer is adjusted for any one of the coils, no other changes need be made until

PICTORIAL WIRING DIAGRAM



KNIGHT 2-TUBE "DX-ER"

a different coil is used. This adjustment is not critical except when you actually want some real DX. It is worth mentioning here that a good aerial is essential for efficient short wave reception, particularly for a set of the "DX-er" type. Both the aerial and lead-in should be well insulated and kept as far away from walls, roofs, etc., as possible.

You will soon learn in using the "DX-er" that broadcast and amateur 'phone stations come in best when the regeneration control is below the point where oscillation starts. Code signals, however, come in best above this point. In working on the short wave bands, keep the set just oscillating, and tune very slowly. The incoming "dit-dit-dah" will tell you that you have a code station. A whistle, on the other hand, should serve as a warning to reduce the regeneration control setting, and then to listen to a 'phone station at this dial setting.

While there is nothing tricky about the operation of the "DX-er," it is well to spend some time in learning how to tune it to obtain best results.

KIT OF APPROVED PARTS

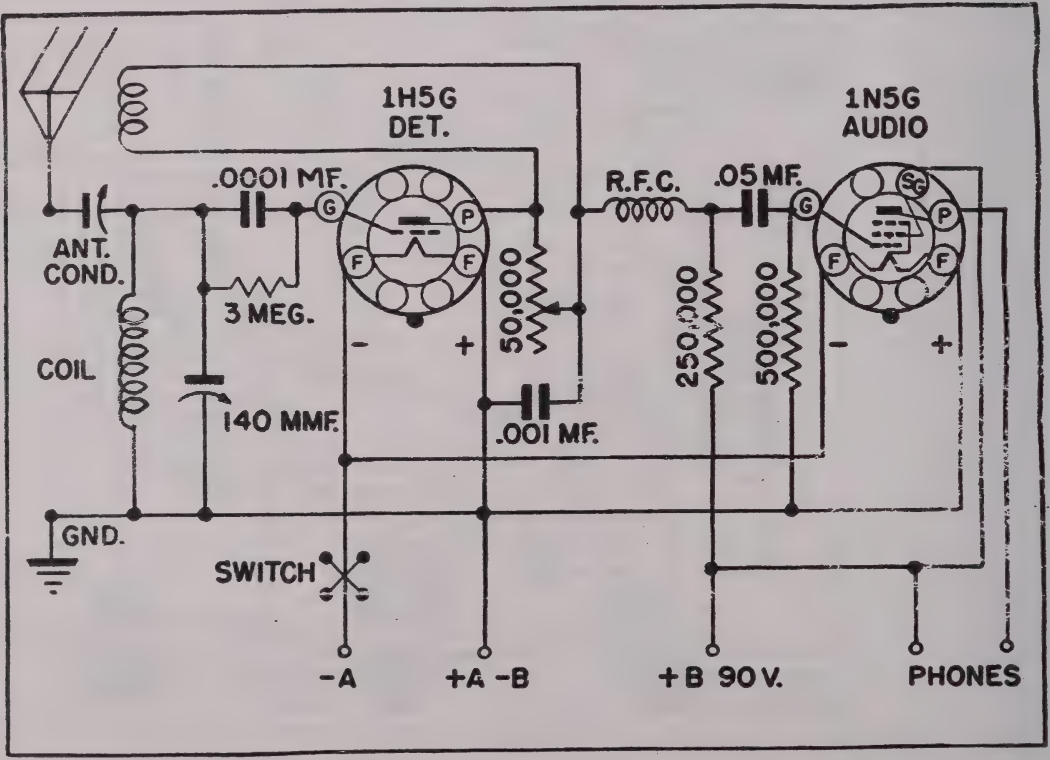
2N791	1	Knight 7 x 8 inch Masonite panel		$0.40
40-254	1	4 prong socket		.24
61-105	1	140 mmfd. variable condenser		.88
30-406	1	50,000 ohm regeneration control		.29
60-331	1	Antenna trimmer condenser		.10
60-800	1	Knight R.F. choke		.15
10-404	1	.0001 mfd. mica condenser		.08
10-415	1	.001 mfd. mica condenser		.12
1-800	1	3 megohm, ¼ watt resistor		.04
1-820	1	250,000 ohm, ½ watt resistor		.05
41-706	1	Package Fahnestock clips		.09
2N239	1	Baseboard, 6" x 8"		.20
55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs		.20
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
40-258	2	Octal sockets	.29	.58
10-460	1	.05 mfd. 400 volt condenser		.08
1-820	1	500.000 ohm ½ watt resistor		.05
42-036	2	Grip clips		.04

ACCESSORIES

9-037	1	Knight type, 1H5G tube		.58
9-047	1	Knight type, 1N5G tube		.73
80-804	1	Knight 1½ volt dry cell		.25
80-800	2	Knight "B" batteries	1.21	2.42
54-050	2	Plugs for "B" batteries	.04	.08
60-670	1	Kit of 4 coils for 9.5 to 217 meters		1.08
60-671	1	Kit of 2 coils for 190 to 550 meters		.96
59-111	1	American Bell 3000 ohm headphone		1.38

SCHEMATIC WIRING DIAGRAM

Diagram below shows top view of tube sockets.



KNIGHT 2-TUBE "DX-ER"

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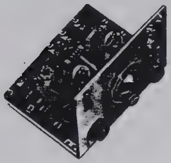

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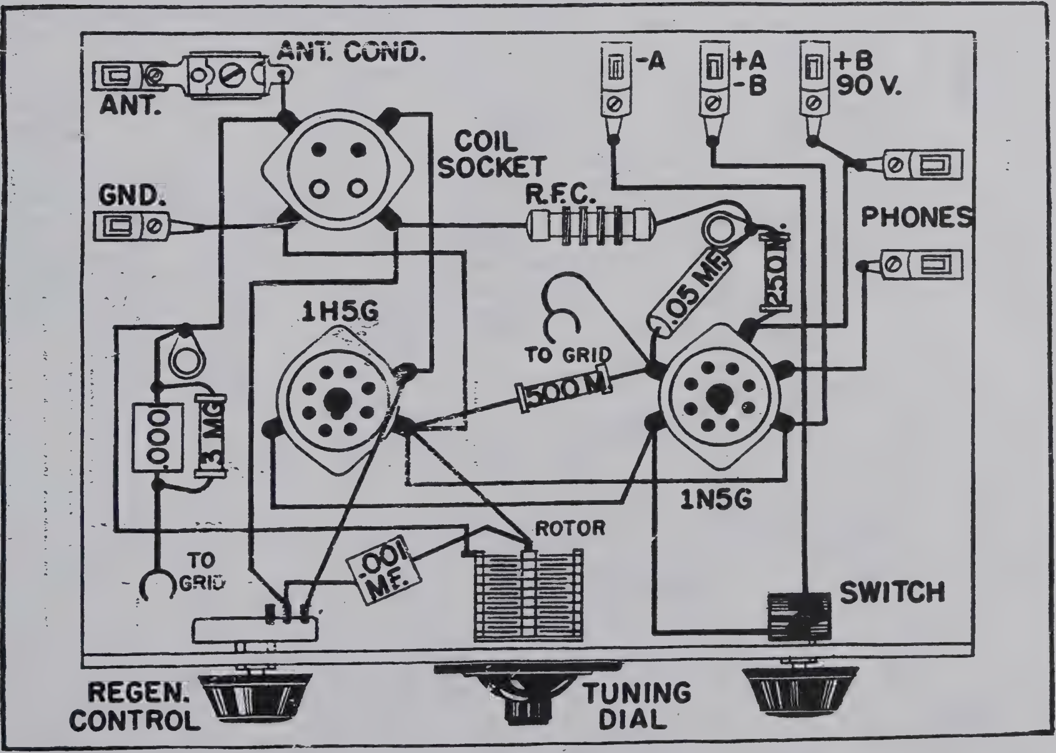
Now test the set to see if it will regenerate. Advance the regeneration control to the right, and a hiss will be heard. If you do not hear this hiss, check the coil socket and the "B" batteries to see that they are wired correctly.

Next, connect the antenna and ground. With these in place and the regeneration control just below oscillation (hissing point), turn the tuning control and you will receive several stations. You will find that adjusting the antenna trimmer will help a great deal. The antenna condenser should be adjusted so that the detector tube will oscillate at all points on the tuning dial. The point of adjustment depends entirely upon the degree of absorption of the antenna circuit from the tuning circuit. Once the trimmer is adjusted for any one of the coils, no other changes need be made until

PICTORIAL WIRING DIAGRAM



KNIGHT 2-TUBE "DX-ER"

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1-820	1	250,000 ohm, ½ watt resistor		.05
41-706	1	Package Fahnestock clips		.09
2N239	1	Baseboard, 6" x 8"		.20
55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs	.15	.30
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
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10-460	1	.05 mfd. 400 volt condenser		.08
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42-036	2	Grip clips	.02	.04

ACCESSORIES

9-037	1	Knight type, 1H5G tube		.58
9-047	1	Knight type, 1N5G tube		.78
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54-050	2	Plugs for "B" batteries	.04	.08
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SCHEMATIC WIRING DIAGRAM

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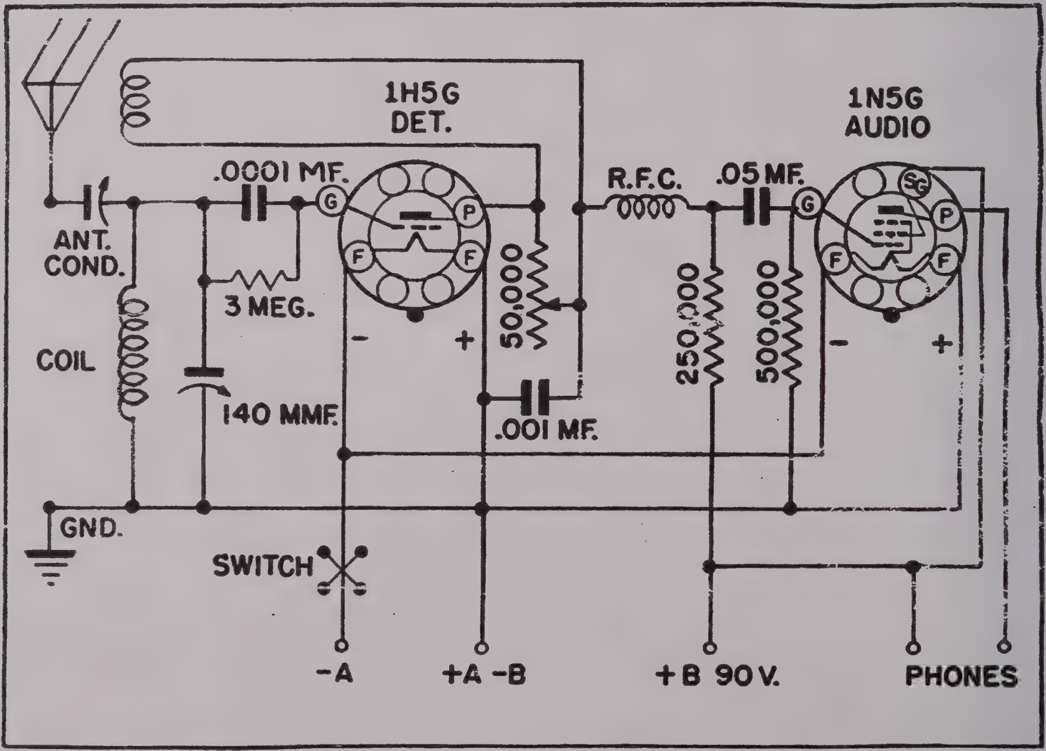

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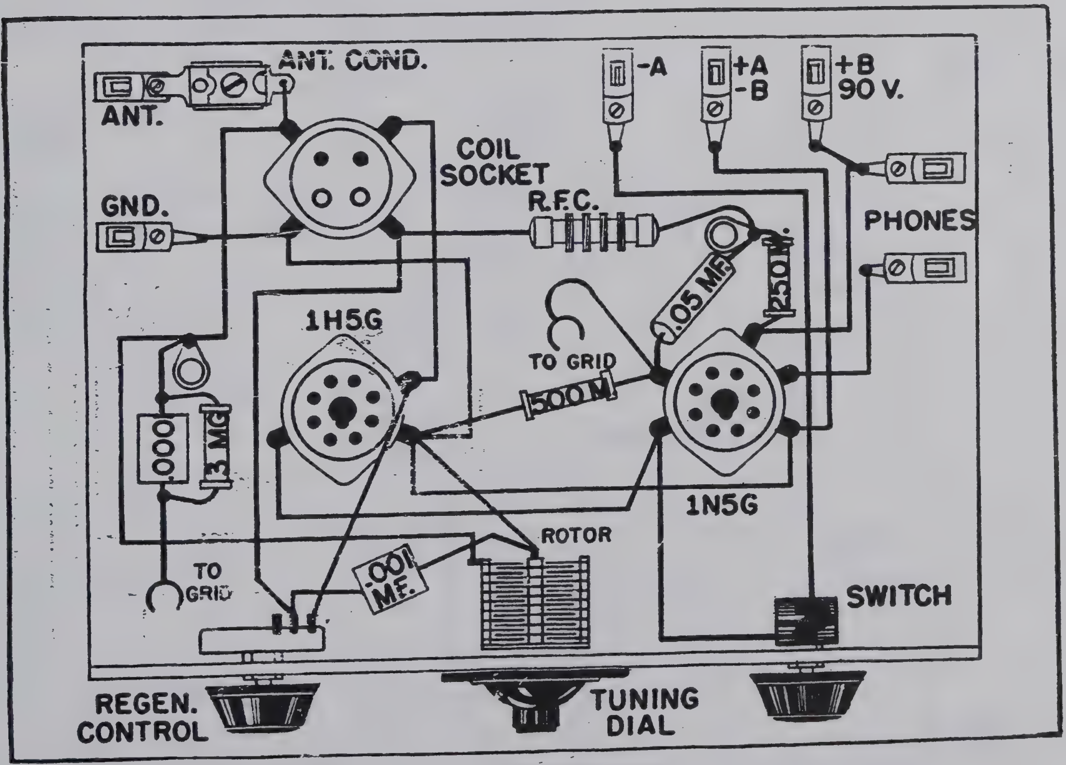
PICTORIAL WIRING DIAGRAM



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10-404	1	.0001 mfd. mica condenser		.08
10-415	1	.001 mfd. mica condenser		.12
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1-820	1	250,000 ohm, ½ watt resistor		.05
41-706	1	Package Fahnestock clips		.05
2N239	1	Baseboard, 6" x 8"		.20
55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs		.30
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
40-258	2	Octal sockets	.29	.58
10-460	1	.05 mfd. 400 volt condenser		.08
1-820	1	500.000 ohm ½ watt resistor		.05
42-036	2	Grip clips		.04

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9-047	1	Knight type, 1N5G tube		.73
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80-800	2	Knight "B" batteries	1.21	2.42
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SCHEMATIC WIRING DIAGRAM

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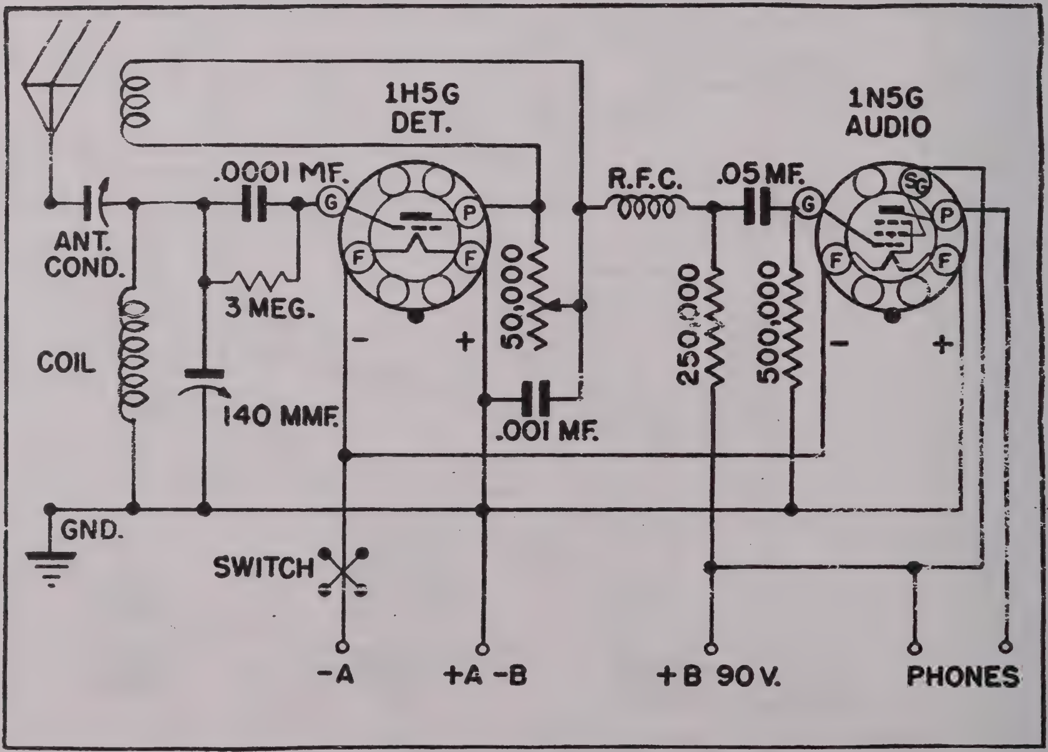

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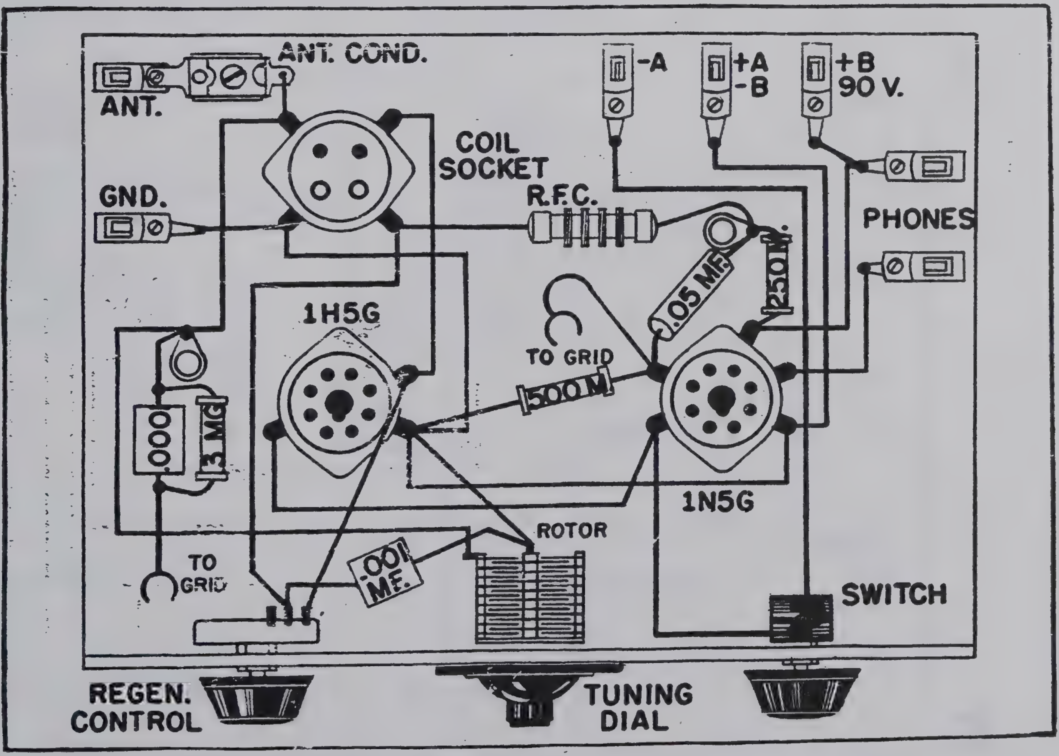
PICTORIAL WIRING DIAGRAM



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10-415	1	.001 mfd. mica condenser		.12
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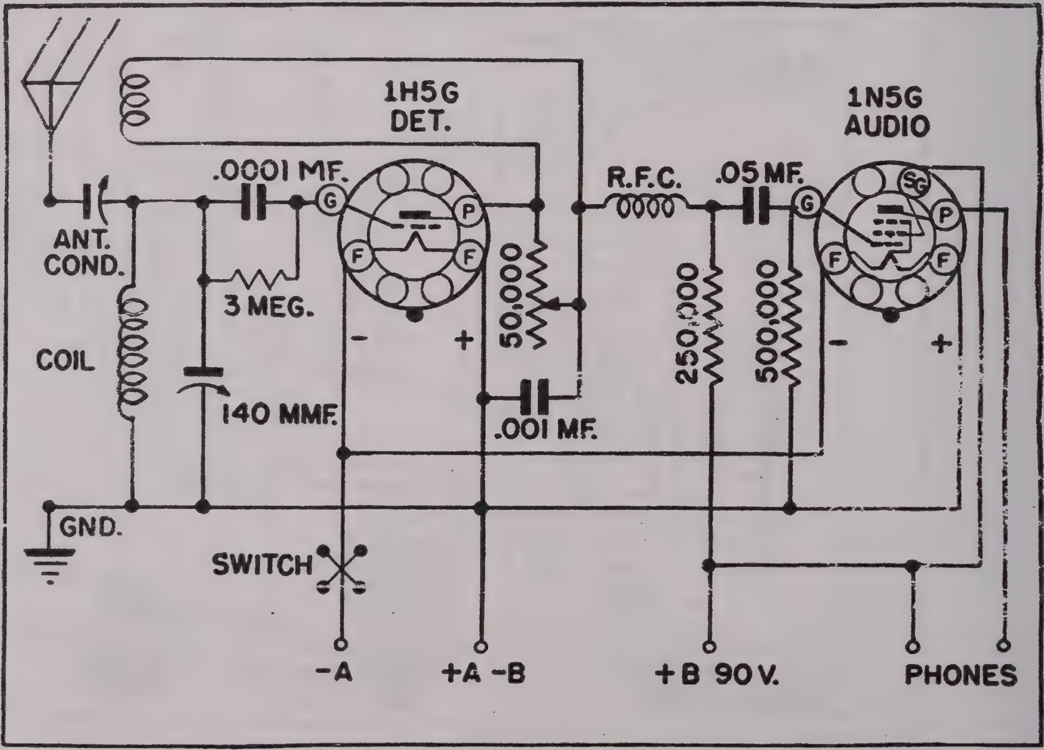
1-820	1	250,000 ohm, ½ watt resistor		.05
41-706	1	Package Fahnestock clips		.05
2N239	1	Baseboard, 6" x 8"		.20
55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs		.20
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
40-258	2	Octal sockets	.29	.58
10-460	1	.05 mfd. 400 volt condenser		.02
1-820	1	500.000 ohm ½ watt resistor		.05
42-036	2	Grip clips		.04

ACCESSORIES

9-037	1	Knight type, 1H5G tube		.58
9-047	1	Knight type, 1N5G tube		.73
80-804	1	Knight 1½ volt dry cell		.29
80-800	2	Knight "B" batteries	1.21	2.42
54-050	2	Plugs for "B" batteries	.04	.08
60-670	1	Kit of 4 coils for 9.5 to 217 meters		1.08
60-671	1	Kit of 2 coils for 190 to 550 meters		.95
59-111	1	American Bell 3000 ohm headphone		1.38

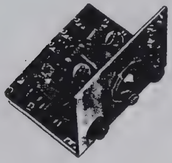
SCHEMATIC WIRING DIAGRAM

Diagram below shows top view of tube sockets.



KNIGHT 2-TUBE "DX-ER"

The 2-Tube "DX-ER" is a dependable battery operated short-wave receiver which can be built quickly and easily. The tuning range is 9.5 to 550 meters when used with proper coils, covering the important foreign and domestic 'phone and code Amateur bands, as well as regular standard broadcast programs.



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After the set has been wired and one of the coils and the two 1.4 volt tubes are in place, connect the "A" battery and notice the filament glow in the tubes. This will serve as a safety check to see if the filaments are wired correctly. No glow indicates that an error has been made in the filament circuit. When the filament glows connect the "B" battery and insert the headphones into the proper Fahnestock clips.

Now test the set to see if it will regenerate. Advance the regeneration control to the right, and a hiss will be heard. If you do not hear this hiss, check the coil socket and the "B" batteries to see that they are wired correctly.

Next, connect the antenna and ground. With these in place and the regeneration control just below oscillation (hissing point), turn the tuning control and you will receive several stations. You will find that adjusting the antenna trimmer will help a great deal. The antenna condenser should be adjusted so that the detector tube will oscillate at all points on the tuning dial. The point of adjustment depends entirely upon the degree of absorption of the antenna circuit from the tuning circuit. Once the trimmer is adjusted for any one of the coils, no other changes need be made until

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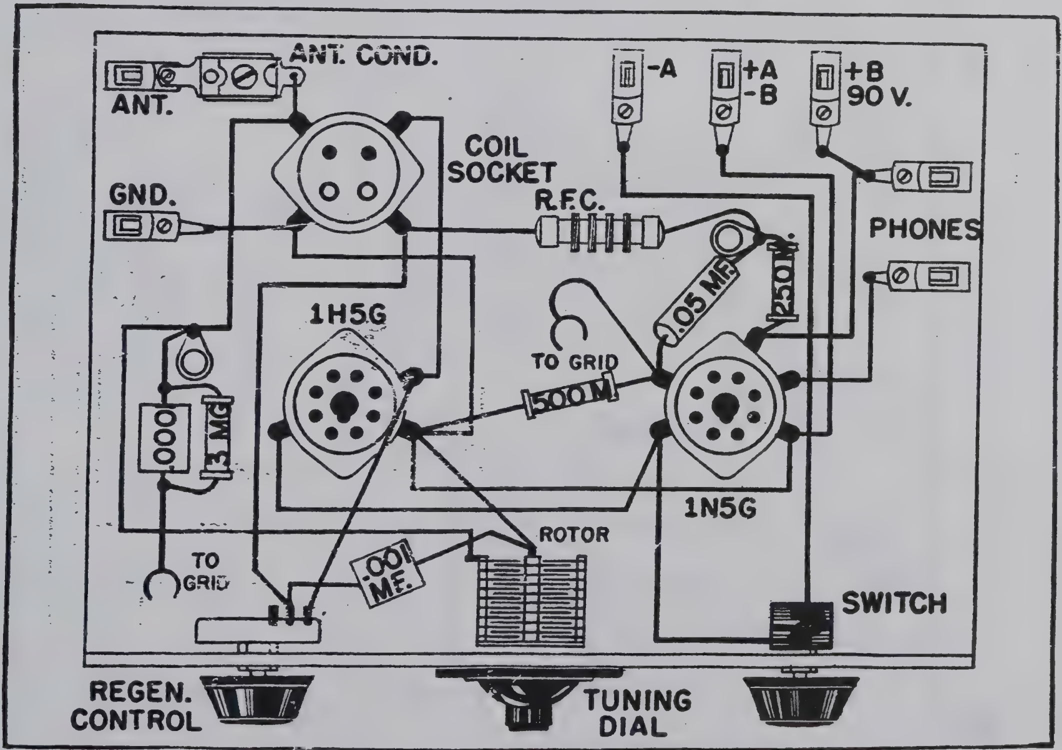

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60-800	1	Knight R.F. choke		.15
10-404	1	.0001 mfd. mica condenser		.08
10-415	1	.001 mfd. mica condenser		.12
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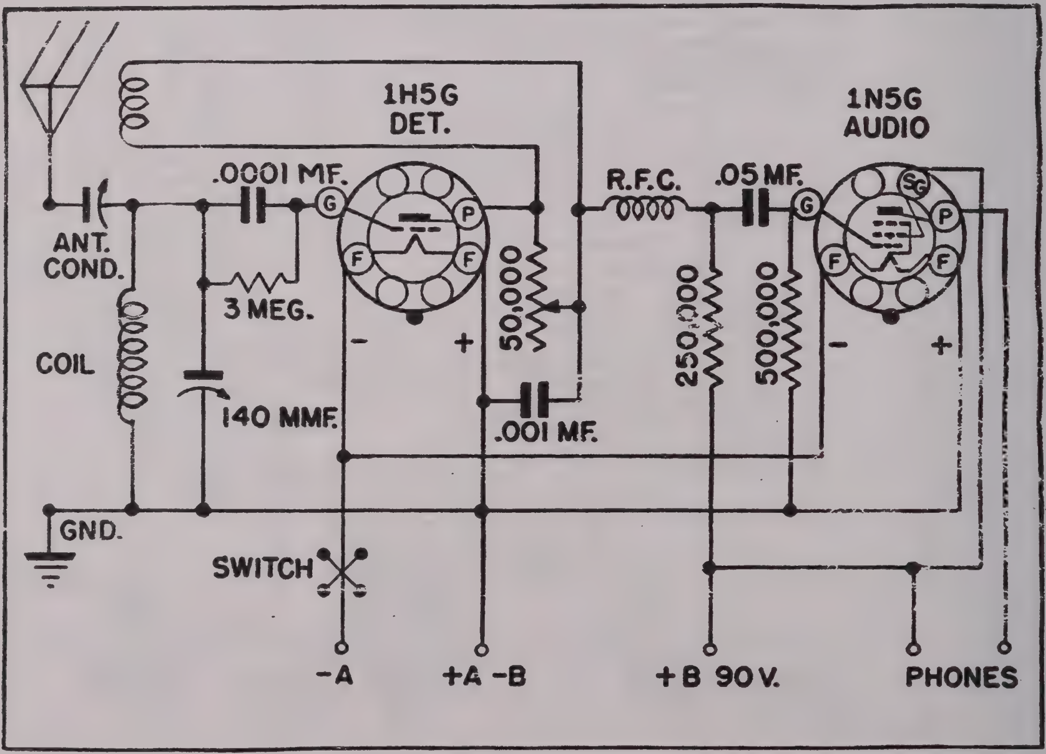
1-820	1	250,000 ohm, ½ watt resistor		.05
41-706	1	Package Fahnestock clips		.05
2N239	1	Baseboard, 6" x 8"		.20
55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs	.15	.30
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
40-258	2	Octal sockets	.29	.58
10-460	1	.05 mfd. 400 volt condenser		.02
1-820	1	500.000 ohm ½ watt resistor		.05
42-036	2	Grip clips	.02	.04

ACCESSORIES

9-037	1	Knight type, 1H5G tube		.58
9-047	1	Knight type, 1N5G tube		.73
80-804	1	Knight 1½ volt dry cell		.25
80-800	2	Knight "B" batteries	1.21	2.42
54-050	2	Plugs for "B" batteries	.04	.08
60-670	1	Kit of 4 coils for 9.5 to 217 meters		1.02
60-671	1	Kit of 2 coils for 190 to 550 meters		.95
59-111	1	American Bell 3000 ohm headphone		1.33

SCHEMATIC WIRING DIAGRAM

Diagram below shows top view of tube sockets.



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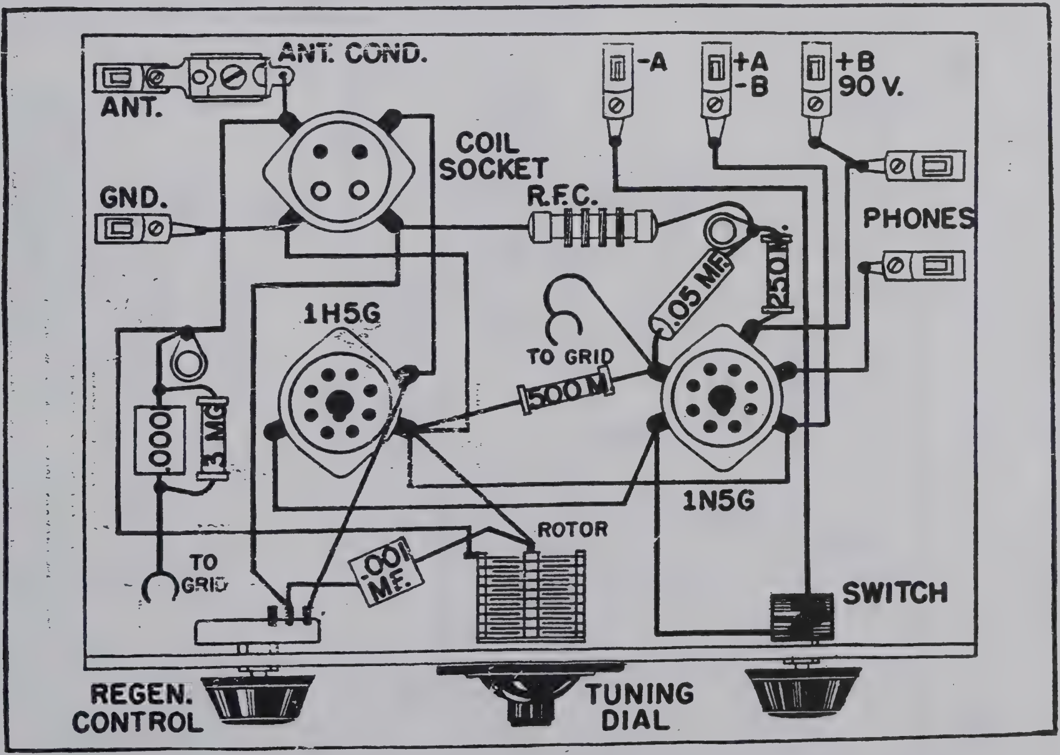
Now test the set to see if it will regenerate. Advance the regeneration control to the right, and a hiss will be heard. If you do not hear this hiss, check the coil socket and the "B" batteries to see that they are wired correctly.

Next, connect the antenna and ground. With these in place and the regeneration control just below oscillation (hissing point), turn the tuning control and you will receive several stations. You will find that adjusting the antenna trimmer will help a great deal. The antenna condenser should be adjusted so that the detector tube will oscillate at all points on the tuning dial. The point of adjustment depends entirely upon the degree of absorption of the antenna circuit from the tuning circuit. Once the trimmer is adjusted for any one of the coils, no other changes need be made until

PICTORIAL WIRING DIAGRAM



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41-706	1	Package Fahnestock clips		.05
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55-321	1	Kurz-Kasch vernier dial		.75
55-150	2	Round knobs		.20
1N615	1	Hardware kit		.20
34-141	1	Rotary "on-off" switch		.22
40-258	2	Octal sockets	.29	.58
10-460	1	.05 mfd. 400 volt condenser		.02
1-820	1	500.000 ohm ½ watt resistor		.05
42-036	2	Grip clips		.04

ACCESSORIES

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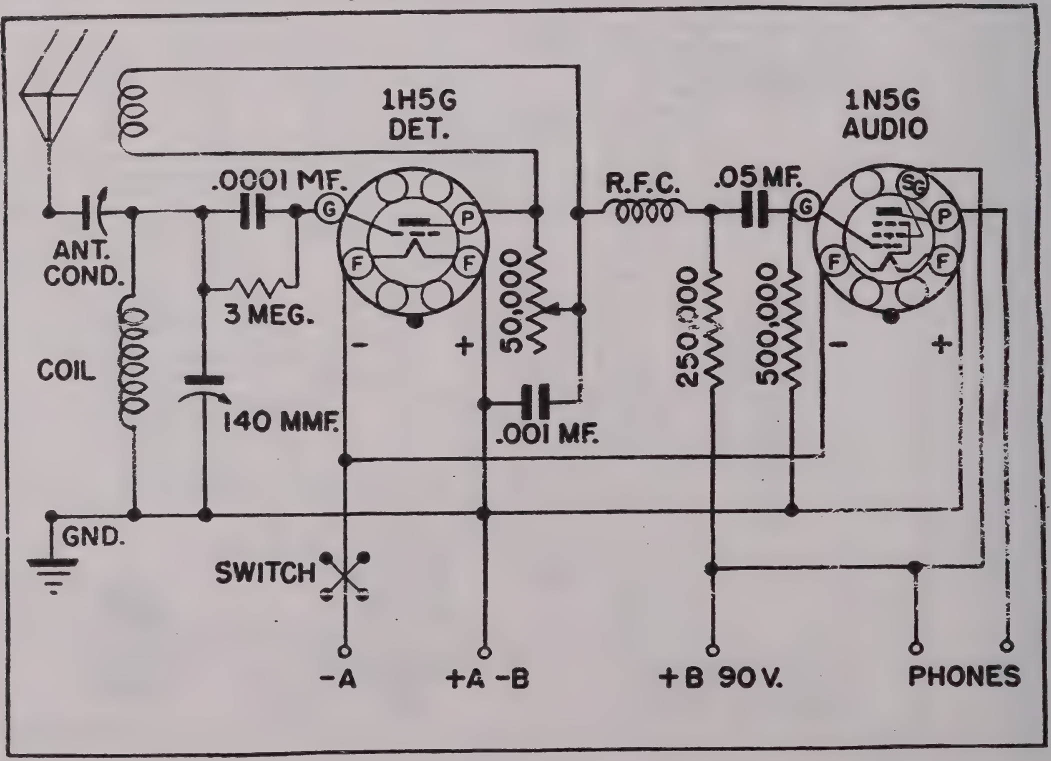
SCHEMATIC WIRING DIAGRAM

Diagram below shows top view of tube sockets.



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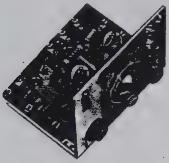

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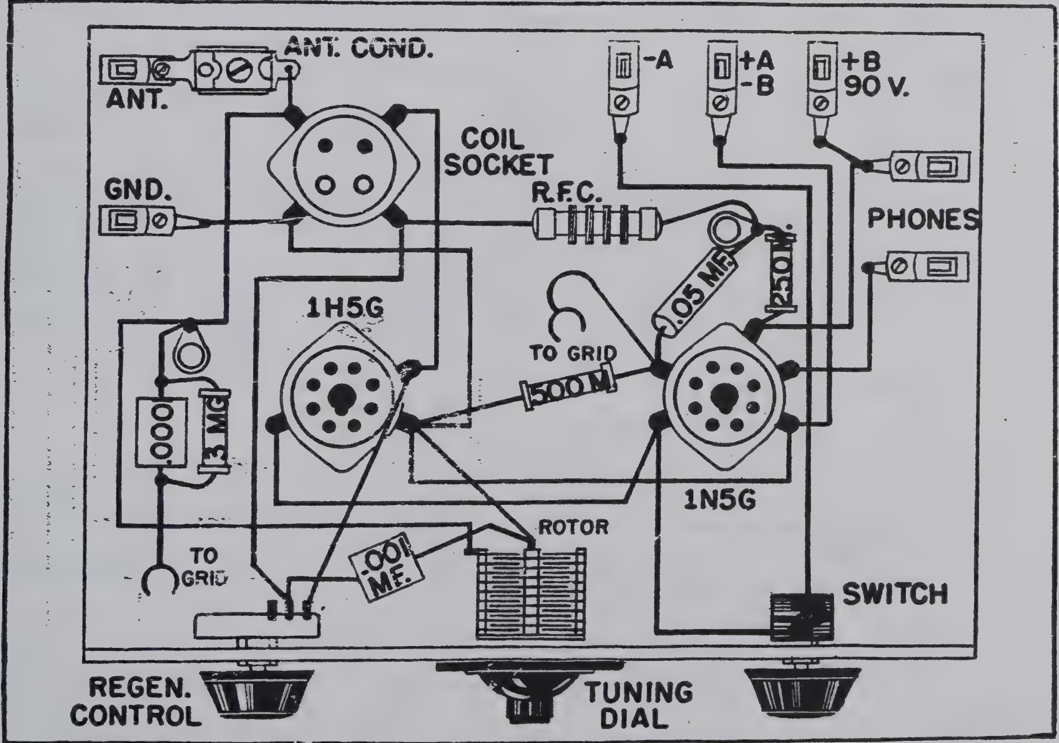

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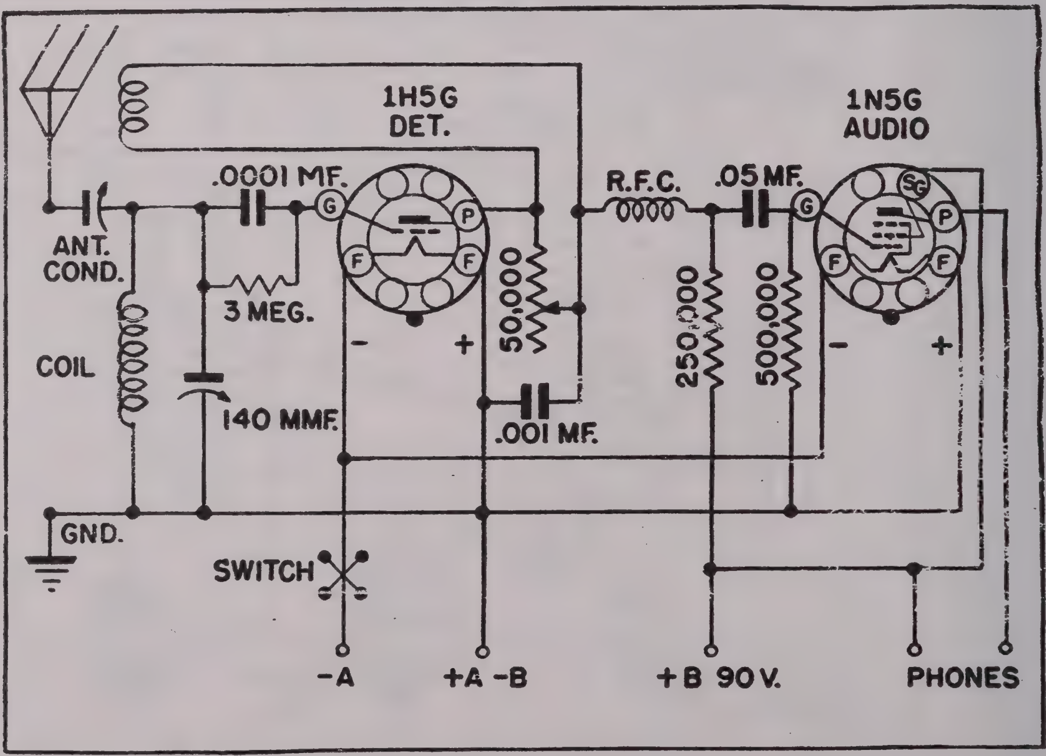
SCHEMATIC WIRING DIAGRAM

Diagram below shows top view of tube sockets.



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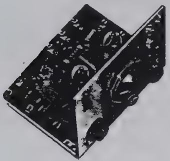

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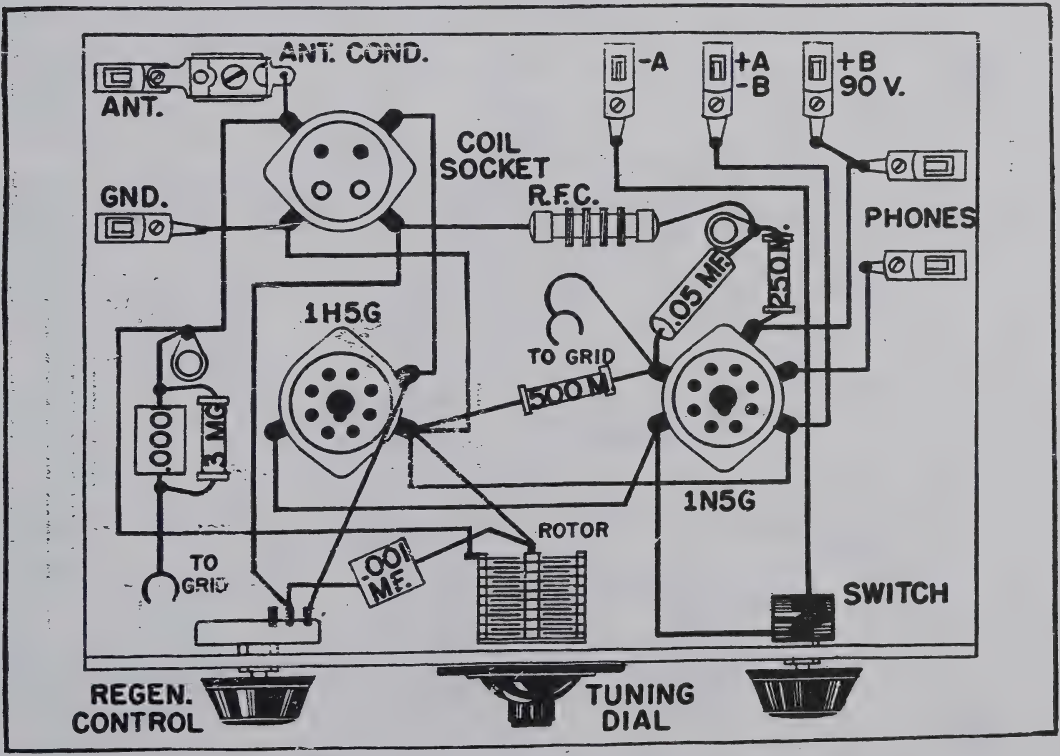

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41-706	1	Package Fahnestock clips	.05
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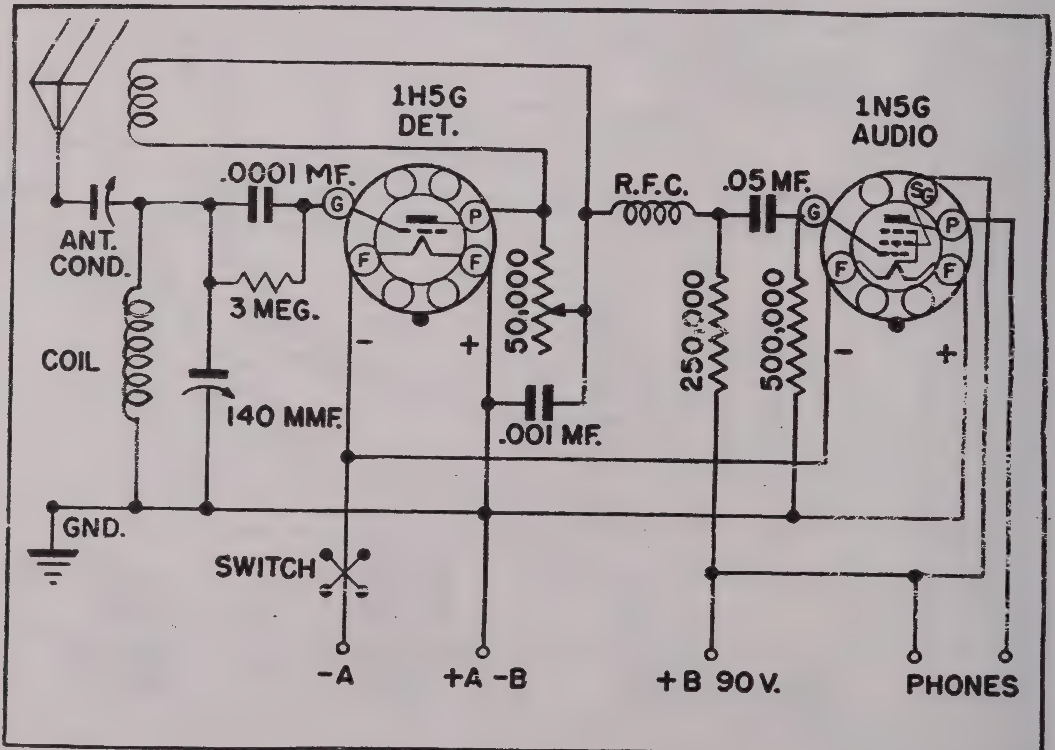

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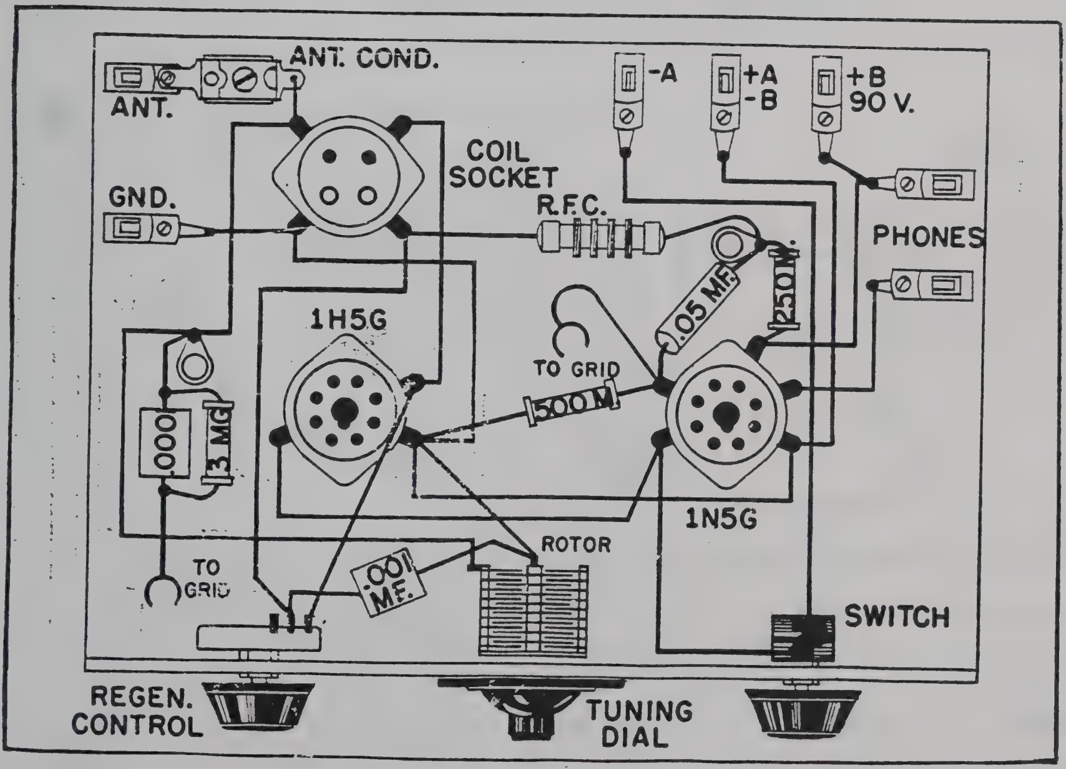

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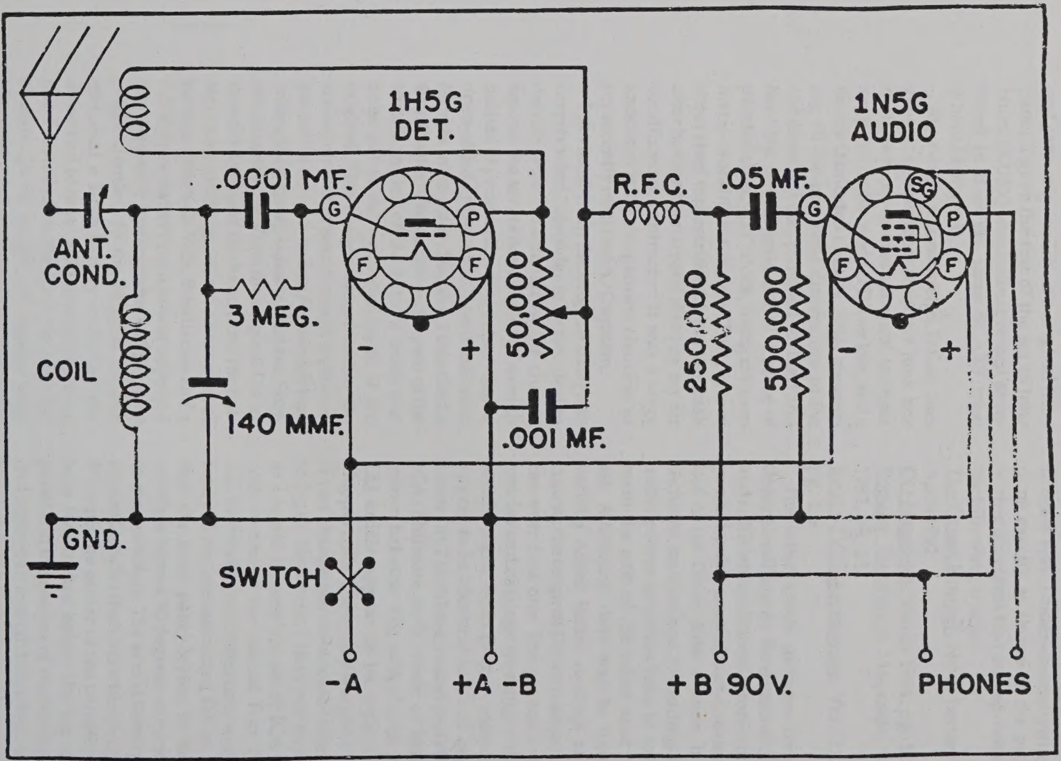

Reconstruction of a Knight DX-er

By Mike Bittner
27215 Sunnyridge Road
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This construction project began with the lucky find of a Knight DX-er at a Southern California Antique Radio Society (SCARS) swap meet. Unfortunately, this DX-er had been completely modified with non-original parts in a crude attempt at transistorization. The only original parts left were the front panel, the knobs and the chassis with its antenna/ground and phone terminals on its back panel. The chassis was badly bent and work-hardened in the center, apparently due to the force of repeated insertion and extraction of tubes and/or the plug-in coils. The only way to straighten out the chassis would have been to completely strip it of parts and hammer it flat again. The non-original plug-in coils that came with the deal were somewhat crudely hand-wound on a variety of used coil forms with the wires held in the coil pins by wedging inch-and-a-half long finishing nails into the pins on the insides of the forms and leaving these nails soldered in place (gives a whole new meaning to the term iron-core coil). I decided to strip and refurbish these coil forms for use in future projects and save only the DX-er's original front panel. I gave the rest of the set to John Hurst (KU6X) who had expressed an interest in it at the same SCARS meet where I bought it.

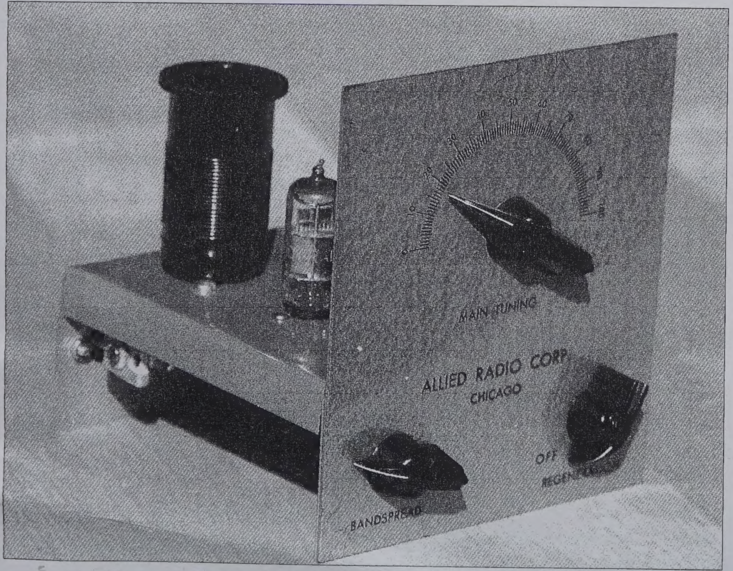

Figure 1: Front view of the reconstructed battery DX-er.

My newly reconstructed DX-er uses generic components from my junk box that are more-or-less identical to those supplied in the original DX-er kits, and a newly fabricated chassis. After measuring all the pertinent dimensions of the old chassis, I cut, punched, drilled and bent the new chassis out of a piece of painted steel, .031" thick, using my own metal- working machinery. This piece of sheet steel was retrieved from the trash after having been tossed there by my air conditioning contractor. It was a large knockout from the plenum chamber of my recently installed A/C system.

I deviated from the original design to correct what I consider to be two design defects. First, to strengthen the chassis against the severe bending that the original had experienced, while preserving its open-sided appearance, I bent half-inch flanges in its sides. Second, I installed a 4-pin battery connector on the rear of the chassis in lieu of the battery leads that poke out of the open right-side of the original. This makes a much neater installation and prevents strain on the regeneration control and on/off switch lugs where the battery leads terminate. Such strain can occur when the original DX-er is moved around the bench and the battery leads are plugged into a heavy set of batteries (two 45-Volt, B-batteries and a 1.5-Volt, A-battery) or a power supply. I made a 4-wire battery cable with battery plugs identical to the original on one end, and a 4-pin battery socket on the other end to mate with the battery plug that I installed on the back panel of the chassis. These plugs and socket were liberated from an old portable radio and a dead A/B battery pack. Other than these two modifications, the reconstructed DX-er conforms to the original in every way. Under-chassis wiring was done exactly as shown in the pictorial wiring diagrams that are reproduced in the following articles:

The Ocean Hopper, News Letter No. 3, April 1992.

CQ Magazine, March 1994, pg. 110.

Popular Electronics Magazine, March 1952, pg. 25.

Radio-TV Experimenter, Vol. 2, 1952, pg. 139.

The latter article includes complete dimensional data for the chassis and panel and sufficient additional information for you to be able to construct an exact replica of the DX-er from scratch. It even includes instructions for adding a 3V4 audio power amplifier tube to complement the pair of 1S5 tubes used in the set. Additional data may be found in various Allied Radio catalogs and, of course, the original DX-er manual if you can ever find one. The photos in these articles and catalogs (except for the CQ article) show 4-pin plug-in coils which appear to be identical to 1-1/2 inch diameter by 2 inch long, round (not ribbed) ICA/Philmore coils made of black or brown bakelite. The coils shown in the CQ article appear to be 5-pin Ocean Hopper coils. These may work in a DX-er if you change the coil socket from 4-pin to 5-pin. However, I have not tried this as I found a complete set of ICA 4-pin coils at one of the annual Fort Tuttle, AZ, hamfests. These latter coils work perfectly in my reconstructed DX-er. Note that the front panel layout in the CQ article is turned 90 degrees with respect to the markings. The actual battery DX-er panel is taller than it is wide (5-1/2" by 5") with the center of the bandset shaft hole two inches below the top of the panel and the centers of the bandspread and regeneration shaft holes three inches apart and one inch above the bottom of the panel. My original front panel does not have dial scale markings for the bandspread tuning capacitor, as shown

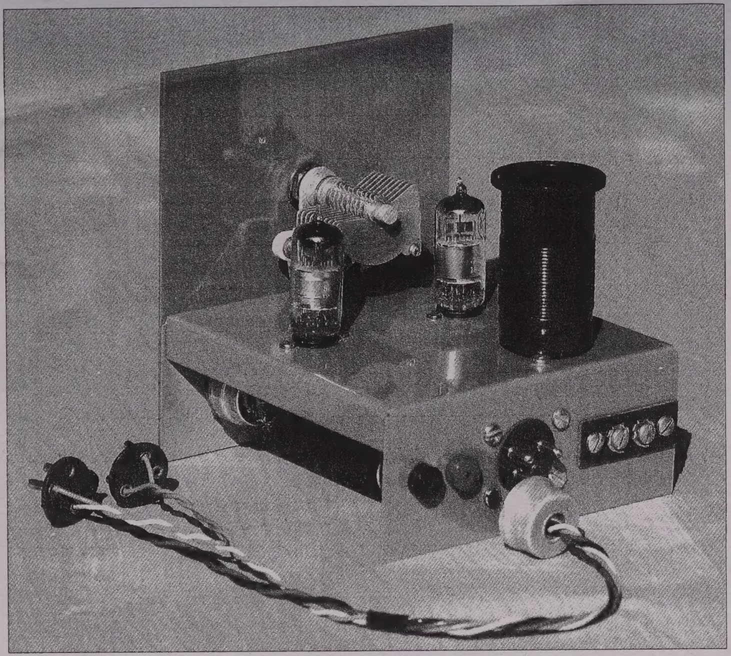

Figure 2: Showing new chassis side-flange (there's one on each side) and new battery cable and mating chassis connector.

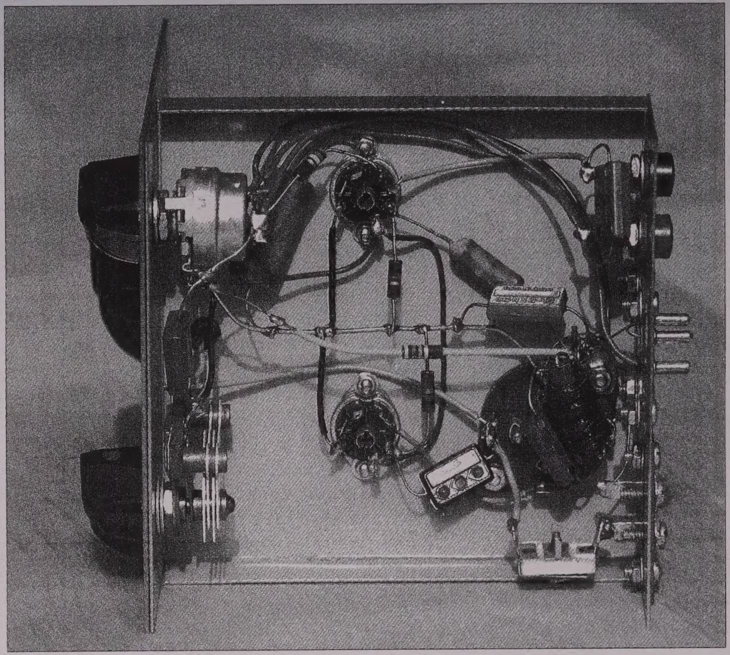

Figure 3: Under-chassis wiring is same as original except for new battery connector.

in the CQ article, but only the label BANDSPREAD, and the bandset capacitor is labeled MAIN TUNING.

Operation of the battery DX-er is the same as other receivers of this general type including the somewhat irritating requirement for having to constantly readjust the regeneration control as you tune across a band due to the increase in feedback that naturally occurs as you tune higher in frequency. I usually set the regeneration control just past the point of oscillation (you hear whistles in the earphones) and then tune the desired station to zero beat. Then I reduce the regeneration to just below the point of oscillation. As anyone who has built a 2-tube regenerative set will tell you, the performance of these little sets is amazing. My thanks to Steve Barnes (K6PFW) for lending me his set of "Ocean Hopper" news letters including the one with the Knight Battery DX-er article.

[Editor's note: The author's prize-winning "Fontana" regen receiver will be featured as a construction project in upcoming issues of Electric Radio.]

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